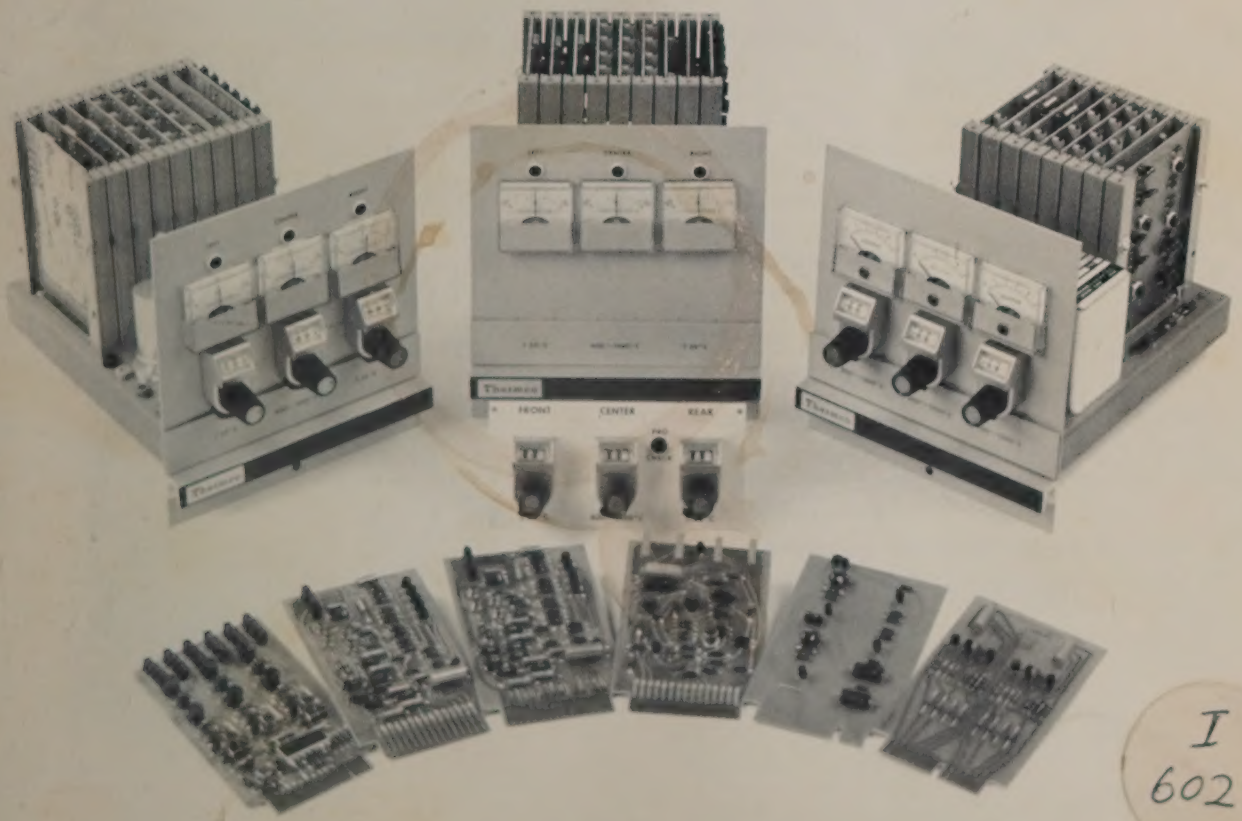
9·F·12 co's

ANA-LOCK CONTROLLERS

models

201
321
331
421
431

VIKING LABORATORIES INC.



I
602

THERMCO PRODUCTS CORPORATION 1465 North Batavia Street Orange, California 92667

TABLE OF CONTENTS

THERMCO®
ANA-LOCK® CONTROLLER MANUAL

Page

SECTION I, DESCRIPTION
- Temperature Control 3
- Controller Furnace Applications
  - Diffusion Furnaces, Models 201, 321, 331 3
  - Conveyor Furnaces, Models 421 and 431 3
- Controller Features 4

SECTION II, SPECIFICATIONS
- Diffusion Series 5
- General Purpose Series 6

SECTION III, INSTALLATION AND INTERFACE
- Preliminary Installation Check 7
- Reading Digital Set Point Dials 8
- Furnace Interface Operations 9

SECTION IV, THEORY OF OPERATION
- Controller Theory 10
- Definition of P/B and R/M Modes 12

SECTION V, CALIBRATION PROCEDURES 13

SECTION VI, TROUBLESHOOTING
- Fault Location Chart 18

SECTION VII, CONTROLLER SYSTEM SCHEMATICS
- Schematic, Series 201 Controller 19
- Schematic, Series 331 Remote 20
- Schematic, Series 321 Controller 21
- Schematic, Series 421 and 431 Controller 22
- Main Chassis Parts List 23
- Parts List and Photo, Series 331 Remote Panel 24
- Back Panels Parts List 25
- Back Panels Photos 26

SECTION VIII, CONTROLLER CIRCUIT CARDS
- Controller Card Requirements 27
- Parts List, Component Layout and Schematics
  - Power Supply 28
  - Clock Card 30
  - Operational Amplifier 32
  - Center Zone Pre-Amplifier 34
  - End Zone Pre-Amplifier 36
  - Pro-Check Light Card 38

SECTION IX, ILLUSTRATIONS 40

SECTION X, PACKING AND SHIPPING 40

® REGD. T.M.

This system, developed by **Thermco Products Corporation,** has been refined by years of experience and represents the ultimate in performance and reliability.

Highest quality components are used throughout. They include silicon solid state FET chopper amplifiers to insure unexcelled sensitivity and stability.

Deviation and output meters used in the controller are of taut band construction to assure freedom from friction, ruggedness and long meter life.

Several models and ranges of controllers are available to suit all of your applications whether it be diffusion furnaces, conveyor furnaces or other Heat Process Systems.

Circuit card plug-in interchangeability, advanced modular design, ease of adjustment and a minimum of maintenance are combined to offer the best instrument in the field of Precision Heat Control.

DIFFUSION FURNACE CONTROLLERS
Model Series 201, 321 and 331

The master-slave four thermocouple control system, long accepted as the best method of establishing and maintaining the critical temperature profiles required in semiconductor processing, is featured in the 201, 321 and 331 series. Calibration for type "R" thermocouples is standard for this series.

Two mode control, proportioning plus reset, together with highest sensitivity, provide unexcelled control, stability and repeatability. See page 12 for a discussion of these two modes. Direct, easily accessible adjustments, having no electronic interaction, offer calibration procedures that are straightforward and time saving.

The series 201, 321 and 331 replace their earlier counterparts, the series 20, 32 and 33 models. Models 201 and 321 may be directly interchanged on a temporary basis in place of the remote 331 providing great flexibility for maintaining equipment availability in the event of controller failure.

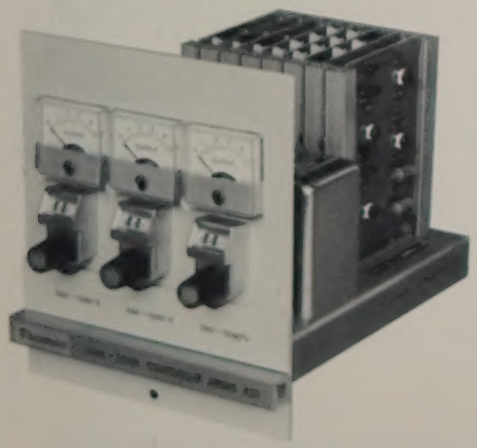


FIGURE 2 Model 431 Ana-Lock Controller

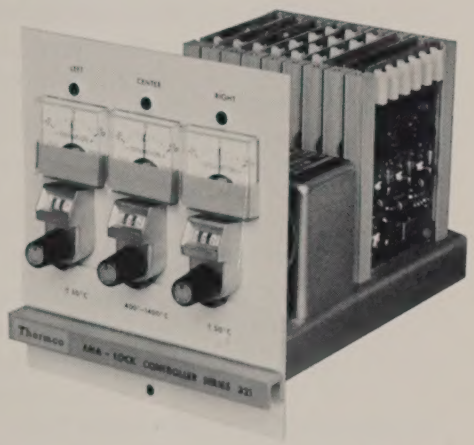


FIGURE 1 Model 321 Ana-Lock Controller

All units feature a simplified system for digital dial setting of furnace temperatures. Digital dial reading is discussed on page 8.

GENERAL PURPOSE CONTROLLERS
Model Series 421 and 431

Independent control channels are featured in this series of controllers, each channel having individual Type K thermocouples and cold junction reference systems.

Two mode control, proportioning plus reset, with wide range proportioning band adjustment offers optimum control for a wide variety of equipment types and processes. See page 12 for a discussion of these two modes.

Each channel is separately capable of controlling up to six SCR power circuits providing great flexibility in process design.

The General Purpose Controllers also feature digital dial temperature setting of high accuracy.

CONTROLLER FEATURES

Features:	Diffusion Furnace Controller			General Purpose Controller	
	Series 201	Series 321	Series 331	Series 421	Series 431
MASTER-SLAVE THERMOCOUPLE SYSTEM	√	√	√		
INDEPENDENT T/C SYSTEM				√	√
CHARACTERIZED POTENTIOMETER	√	√	√		
REMOTE SET-POINT CONTROLS			√		
PRO-CHECK INDICATORS		√	√		
DEVIATION METERS		√	√		
OUTPUT METERS	√			√	√

FIGURE 3 Ana-Lock Controller Features

MASTER-SLAVE THERMOCOUPLE SYSTEM

This is a differential system in which the center (master) zone temperature is set conventionally and compares its thermocouple output with a precise reference voltage. The end (slave) zones compare their respective thermocouple outputs with a reference thermocouple located in the center (master) zone. This effectively forces the end zones to track the master center zone temperature setting. Maintenance of accurate flat zone profiles for semi-conductor diffusion and other super-critical tube furnace applications is thus assured. The master-slave system is standard on models 201, 321 and the 331 remote controllers.

INDEPENDENT THERMOCOUPLE SYSTEM

This system is used in models 421 and 431 and uses separately referenced and functionally independent control channels, giving two zone and three zone control respectively.

CHARACTERIZED POTENTIOMETERS

The center zone set point potentiometer is matched to the thermocouple output vs. the temperature characteristic curve, thus maintaining an accurate relationship between dial reading and set point temperature. This feature is standard with R and S thermocouples where the output curve is distinctly non-linear.

REMOTE SET POINT CONTROLS

Set point dial and Pro-Check light assembly are mounted separately from the controller (maximum distance not to exceed 20 feet) on a remote panel. This remote panel is usually installed in a laminar flow station at the load end of the furnace or other convenient remote location. This feature is standard on the Model 331 controller only.

PRO-CHECK INDICATORS

Each zone is provided with a warning lamp and deviation system which turns on its lamp when temperature deviates from the set point more than plus or minus 2°C (nominal factory setting). These limits may be field adjusted from 1° to 10°C deviation. All adjustments are independent. An additional circuit provides for the actuation of a remote warning Pro-Check lamp to indicate when **any** zone exceeds a limit setting. This feature is standard on the Models 321 and 331 controllers.

DEVIATION METERS

Each zone of the Models 321 and 331 is equipped with a taut band D'Arsonval meter, indicating temperature deviation from control point.

OUTPUT METERS

Each zone of the Models 201, 421 and 431 is equipped with a taut band D'Arsonval meter indicating output current of that controller zone.

SPECIFICATIONS, DIFFUSION SERIES

ANA-LOCK CONTROLLER, DIFFUSION FURNACE SERIES, MODELS 201, 321 and 331.

1. **CENTER ZONE TEMPERATURE RANGE** — **Standard:** Calibrated 400°C to 1400°C. Adjusted by digital Set Point Dial. Type R (platinum-platinum, 13% rhodium) thermocouple. Four thermocouple system.
   Alternate 1: 200°C to 1200°C temperature range, for Type R thermocouple.
   Alternate 2: Type S (platinum-platinum 10% rhodium) thermocouple calibrations, in above temperature ranges.
2. **END ZONE TEMPERATURE RANGE** — −50°C to +50°C referenced to center zone temperature. Adjusted by Digital Set Point Dial.
3. **STABILITY** — Long term stability of ± 1 microvolt.
4. **CONTROL SENSITIVITY** — With minimum Proportional Band, a 0.001°C shift from control point will produce at least 5% power change.
5. **AMBIENT TEMPERATURE** — Optimum operation between 0°C and 50°C.
6. **AMBIENT TEMPERATURE EFFECTS** — Ambient temperature change of ±25°C will produce a ±2.5°C, or less, change in furnace temperature.
7. **REPEATABILITY OF SET POINT** — Any setting of the Set Point dial repeatable to within ¼°C.
8. **RESOLUTION OF SET POINT** — Center Zone: 0.2°C.
   End Zones: 0.02°C.
9. **PROPORTIONAL BAND** — Proportional Band adjustable 0.5°C to 10°C as a front panel adjustment.
10. **RESET RATE** — Reset is adjustable 0.5 to 10 resets per minute as a front panel adjustment.
11. **OUTPUT TO LOAD** — Proportional current output to load from each zone is 0.1 to 5 ma into 1000 ohms.
12. **METER INDICATION** — **201:** Output Meter 0-5 ma monitoring output current.
    321, 331: Deviation meters, −30°C to 0 to +30°C monitoring temperature deviation from controller setting.
13. **THERMOCOUPLE BREAK PROTECTION** — An open thermocouple in any zone will cause that zone output current to go to zero.
14. **PRO-CHECK (SERIES 321, 331)** — Alarm lights for each zone. Factory set to ±2°C from set point. Field adjustable within limits of 1 to 10°C range.
15. **REMOTE PANEL (SERIES 331 ONLY)** — Set Points and single Pro-Check lamp wired for remote panel installation up to 20 feet from controller.
16. **NOISE REJECTION** — Noise rejection is greater than 120 db.
17. **LINE VOLTAGE VARIATIONS** — 10% line voltage shift will cause a temperature change no greater than ±1 microvolt (~ ±0.1°C).
18. **POWER REQUIREMENTS** — Input voltage: 108 to 132 volts AC, 50/60 Hz. 15 Watts maximum.
19. **DIMENSIONS: ENCLOSURE** — Height 6.50" maximum, Width 6.00" maximum, Depth 11.75" maximum.
    PANEL — Height 8.25" maximum, Width 7.25" maximum.
    REMOTE — **(331 only)** Height 3.0", Width 5.87", Depth 3.0".
20. **SHIPPING WEIGHT** — Complete, 18 pounds maximum.

ANA-LOCK CONTROLLER, CONVEYOR & INDUSTRIAL APPLICATIONS,

Model 421 Two Complete Independent Channels.
Model 431 Three Complete Independent Channels.

1. **CHANNEL TEMPERATURE RANGE**—**Standard:** Calibrated 200°C to 1200°C. Adjusted by Digital Set Point dial. Type K (chromel-alumel) thermocouple.
   Alternate: 0°C to 1000°C temperature range. Type K (chromel-alumel).
2. **STABILITY**—Long term stability of ± 1 microvolt.
3. **CONTROL SENSITIVITY**—With a minimum Proportional Band, an 0.01°C shift from control point will produce at least 5% power change.
4. **AMBIENT TEMPERATURE**—Optimum operation between 0°C and 50°C.
5. **AMBIENT TEMPERATURE EFFECTS**—Ambient temperature change of ± 25° will produce a ± 2.5°C, or less, change in furnace temperature.
6. **REPEATABILITY OF SET POINT**—Any setting of the Set Point dial repeatable to within ¼°C.
7. **RESOLUTION SET POINT**—Each Channel: 0.2°C.
8. **PROPORTIONAL BAND**—Proportional Band adjustable 5°C to 100°C as a front panel adjustment.
9. **RESET RATE**—Reset is adjustable 0.5 to 10 resets per minute as a front panel adjustment.
10. **OUTPUT TO LOAD**—Proportional current output to load from each channel is 0.1 to 5 ma into a range of 1000 to 4700 ohms.
11. **METER INDICATION**—Output Meters; 0 to 5 ma monitoring output current.
12. **THERMOCOUPLE BREAK PROTECTION**—An open thermocouple in any channel will cause that channel output current to go to zero.
13. **NOISE REJECTION**—Noise rejection is greater than 120 db.
14. **LINE VOLTAGE VARIATIONS**—10% line voltage shift will cause a temperature change no greater than ± 1 microvolt (~ ± 0.1°C).
15. **POWER REQUIREMENTS**—Input voltage: 100 to 125 volts AC, 50/60 Hz. 15 watts maximum.
16. **DIMENSIONS: ENCLOSURE**—Height 6.50" maximum, Width 6.00" maximum, Depth 11.75" maximum.
    PANEL—Height 8.25" maximum, Width 7.25" maximum.
17. **SHIPPING WEIGHT (Complete)**—18 pounds maximum.

GENERAL: The Ana-Lock controller is shipped as part of the furnace assembly mounted in its own shielded case as part of the control panel. Each controller is factory adjusted and calibrated to a particular furnace system.

IDENTIFICATION PLATE: An identification plate is mounted inside the controller housing on top of the power transformer. This plate identifies Thermco's serial number, the temperature range of this particular controller, the thermocouple type that the instrument is calibrated for and the work order number. The thermocouples of a furnace system must match those called out by this plate for proper operation.

CONTROLLER CHECK: Loosen screw in lower center of controller front panel and gently slide controller out of housing. Check to see that all cards are firmly in place. Also, examine each meter to be certain that needles are free and are not bent. Blow out any packing or other foreign material from both top and bottom of chassis. Return controller to its housing and tighten front panel screw.

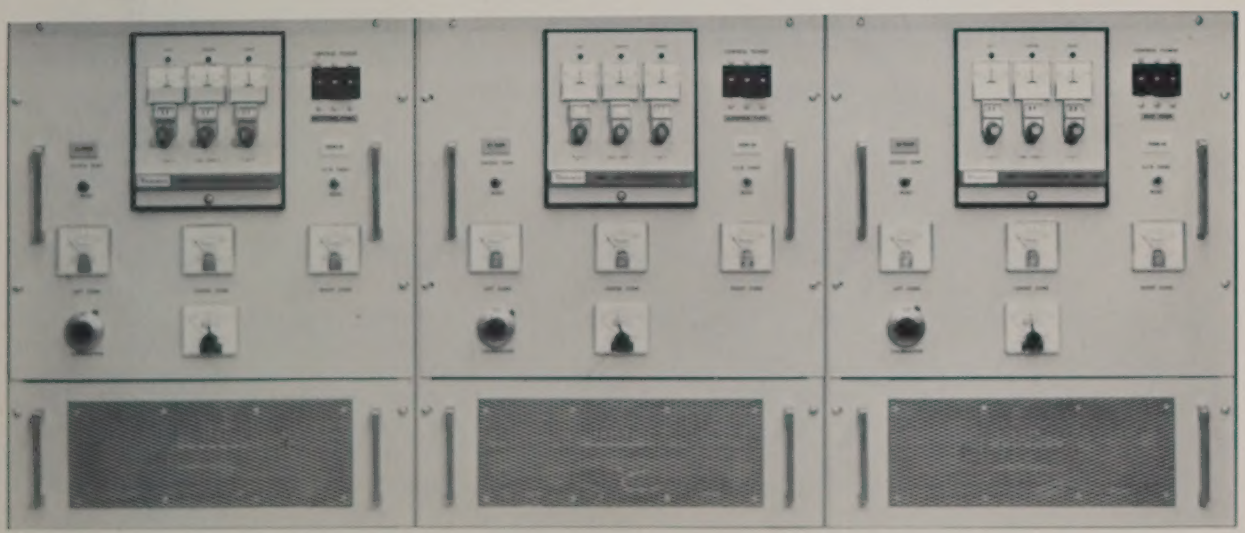


FIGURE 4. Diffusion Furnace Controller Installation

SECTION III

READING DIGITAL SET POINT DIALS

I. DIFFUSION FURNACE CONTROLLERS

Models 201, 321 and 331 (331 has remote set point dials).

A. Center zone set point dial, minimum temperature is 400°C, with a setting range of 1000°C.

1. Standard Range 400°C to 1400°C (TYPE R THERMOCOUPLE) (Consult specifications for other ranges)
2. Subtract 400°C from desired temperature to obtain dial setting.
   a. Example: To set a temperature of 1042°C (1042 − 400 = 642°C),

      set | 6 | 4 | 2 | on center zone digital dial.

   b. Resolution is further improved by subdivision of third dial into 1/5 degree increments.

B. End Zone Set Point Dials

1. Range 100°C (−50°C to 0 to +50°C) referenced to center zone temperature.

   NOTE: An end zone dial setting of | 5 | 0 | 0 | will cause end zone and center zone temperatures to be equal.

   a. Example 1: To set a positive **offset** temperature of +16.5°C, add

      | 5 | 0 | 0 | to this temperature (16.5°C + 50.0 = 66.5°C).

      Set | 6 | 6 | 5 | on end zone digital dial.

   b. Example 2: To set an **offset** temperature of −14.7°C, add algebraically 50.0 to this temperature (50.0 − 14.7 = 35.3°C). Set

      | 3 | 5 | 3 | on end zone digital dial.

   c. The third dial provides resolution to better than a 1/10°C increments.

II. GENERAL PURPOSE CONTROLLERS

Models 421 (2 channels) and 431 (3 channels).
Independent thermocouples are used for all channels.

1. Standard Range 200°C to 1200°C (Type K thermocouple). Minimum temperature is 200°C and setting range is 1000° C. (Consult specifications for other ranges).
2. Subtract 200°C (basic temperature) from desired temperature to obtain dial setting.
   a. Example: To set a temperature of 1042°C, (1042 − 200 = 842°C),

      set | 8 | 4 | 2 | on digital dial.

   b. Resolution is further improved by subdivision of third dial into 1/5°C increments.
3. Set each independent channel in the same manner.
4. An optional temperature range of 0 to 1000°C is available in which temperatures are read directly from the digital dial with no correction for minimum base temperature.

FURNACE INTERFACE OPERATIONS

MECHANICAL CHECK-OUT

Prior to electrical start-up, verify that all mechanical and electrical connections and fittings are in place and secure.

EXCESS TEMPERATURE SYSTEM PROTECTION CHECK

Once the furnace temperature has stabilized at controller set point, check the Excess Temperature System by turning RED NEEDLE counter clockwise to a point just **below** the BLACK NEEDLE on the Excess Temperature Meter. The power circuit breaker will trip **off** and an audible alarm will sound. Reset the RED NEEDLE to some point **above** the black (indicating) needle and then reset the power breaker to **on** restoring power.

INITIAL START-UP

Refer to the particular furnace operating manual for proper start-up procedures. During initial warm-up period do not leave furnace unattended.

FIGURE 5 Diffusion Furnace

FIGURE 6 Conveyor Furnace

DIFFUSION FURNACE CONTROLLERS

THERMOCOUPLE SYSTEMS

Two thermocouple systems are provided in each furnace heating tube chamber. They are all located along the horizontal center line of this chamber. The primary thermocouple system (4 thermocouples) is used with the controller and represent the sensing monitors for control of chamber temperatures in the center and end zones. The secondary thermocouple system (3 additional thermocouples) monitor the condition of possible excess temperature occurring within the chamber in all zones.

The 4 control thermocouples consist of a master and a reference couple in the center zone and a control thermocouple located at each end zone.

All thermocouple assemblies should be checked to verify that no ceramic sheaths are broken and that all clamps are tight.

GENERAL PURPOSE CONTROLLERS

THERMOCOUPLE SYSTEMS

There are two systems of thermocouples within the conveyor furnace. The first of these systems is related to the Ana-Lock Controllers and is temperature sensing input for these instruments. The second system is the Excess Temperature Alarm System. There is one controller thermocouple for each zone of the furnace. That is, two model 431 controllers would have 6 independent zone thermocouples along the length of the muffle.

Check to see that no thermocouple ceramic sheaths are broken or that any thermocouple clamps are loose or missing.

FURNACE PROFILE

Furnace is now ready to profile. Refer to the Conveyor Furnace manual for setting the controller, SCR bias adjustments and belt speeds to obtain proper Time/Temperature profiling procedure.

CONTROLLER THEORY

Exacting temperature control of either a diffusion or conveyor furnace system depends upon the 10 microvolts per degree or less that are available from appropriately positioned thermocouples. Precision control techniques are required to convert a temperature deviation at the microvolt level into the kilowatts of power necessary to drive the furnace tube heater elements. Thermco has met this challenge with its new series of Ana-Lock controllers.

A typical control channel is represented by a Model 201 Controller. The center zone can be used as an example of Thermco two mode controller action. Refer to the block diagram of a Model 201 Controller (figure 7) for more detailed data.

The thermocouple EMF, applied through resistor R, is compared to the set point EMF. This EMF is determined by the setting of P applied to the summing point **"X"** through resistor 100 R. These EMF's are of opposite sign and will produce, at the summing point, **"X,"** a zero differential signal when the thermocouple temperature EMF matches that set by the digital dial control. The thermal potentials and electrical noise problems, typical in millivolt level circuits, necessitate a more accurate and stable system for reference voltage. This is made possible by the ratio of R to 100 R, thus allowing a 100 times higher reference potential to be used.

When the thermocouple EMF **exceeds** the set point EMF, a positive differential signal is produced. A negative differential signal occurs when the thermocouple EMF is **below** the set point EMF. This differential signal is applied to the modulator (chopper) input from the summing point **"X."** The modulator then compares the summing point differential signal with a signal produced by the cold junction compensating circuit.

This circuit produces a small offset signal changing with ambient temperatures and compensating the effect of these ambient changes on controller inputs.

As these three inputs to the modulator balance to a zero differential signal, the tem-

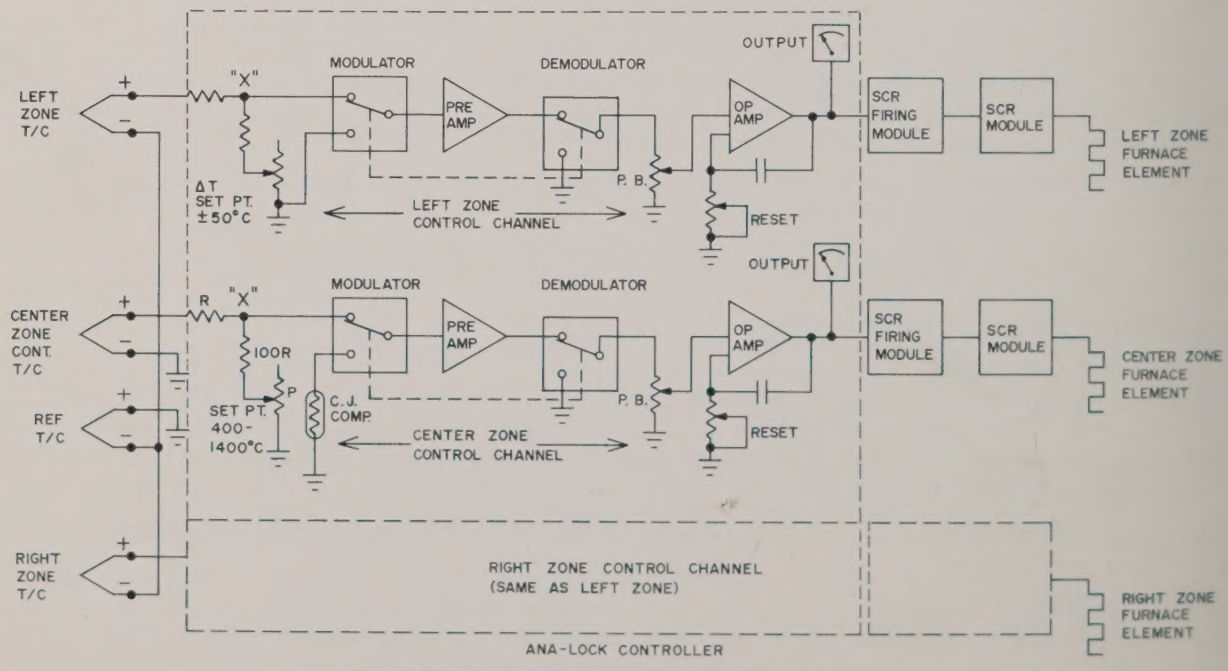


FIGURE 7 Block Diagram Model 201 Controller

perature is equal to the digital set point and the system is satisfied (no corrective output is produced).

If a temperature difference from set point exists, the modulator will produce a square wave signal whose peak-to-peak amplitude is equal to this difference potential.

The direction of temperature difference determines the relative polarity of the square wave produced. This small difference signal (typically, 13 microvolts P-P/°C) must be amplified to a usable level. The pre-amplifier boosts signal level to approximately 80 mv, P-P or about 6000 times. At this level, the signal is demodulated producing a DC signal, nominally 40 mv (average)/°C temperature difference, with polarity a function of the direction of temperature deviation.

This D.C. signal is applied across the proportioning band potentiometer. Functioning as a "gain control" in the input of the operational amplifier, this potentiometer adjusts the relative change in controlled power output per degree of temperature deviation.

The Operational Amplifier acts upon the 40 mv/°C signal to produce, at full gain, a 100% power output for a 20 mv signal (equivalent 0.5°C). The reaction is proportionate for lesser D.C. signals. The immediate reaction of the proportioning control is further supplemented by reset action. (See page 12 for a more detailed description of Proportional Band and Automatic Reset.) In the Operational Amplifier a sustained offset signal produces, through integration, increased compensation of output power until the desired temperature control point is reached.

The rate at which this secondary compensating effect occurs is determined by the reset potentiometer calibrated in repeats per minute. Amplification in the operational amplifier is basically 250 times (for 1000 ohm load). This is modified by reset action gain in excess of 100 times producing a possible total Operational Amplifier gain of 25,000 or more. Output ranges between 0 to 5 ma for control of an appropriate power device. This output current is displayed on the output meter.

Thermco controller models 321 and 331 incorporate a temperature deviation meter for which a meter amplifier is provided as a part of the Operational Amplifier card.

The end zones duplicate the action of the center zone except for input circuitry. Both end zones use a differential thermocouple system, thus no cold junction compensation is required.

POWER SUPPLY CARD

The power supply provides a regulated plus and minus 30 volts D.C. for use in all controller circuits.

CLOCK CARD

The clock card applies a 60 Hz line source into a Schmidtt trigger circuit which drives a conventional flip-flop providing dual 30 Hz square wave outputs (A and $\overline{A}$) to drive the modulator and demodulator circuits.

LIGHT CARD

Three dual comparators are connected, each to its appropriate zone pre-amplifier output. They compare the output of a zone to its reference voltages monitoring over and under temperature limits.

If zone temperature deviation exceeds either limit, the comparator amplifier causes a lamp driver to switch on. If **any zone** Pro-Check lamp is turned ON, the related diode logic causes a relay driver to turn ON, energizing the REMOTE Pro-Check lamp. This relay provides isolation between controller circuitry and a 120 volt remote lamp circuit.

The remote Pro-Check lamp may be arranged in one of two ways. The Model 321 Controller has its remote lamp, an incandescent bulb, located on the GT Stripe or top furnace trim. The Model 331 Controller remote Pro-Check lamp (neon) is located on the remote control panel assembly.

DEFINITION OF PROPORTIONAL BAND AND RESET MODES

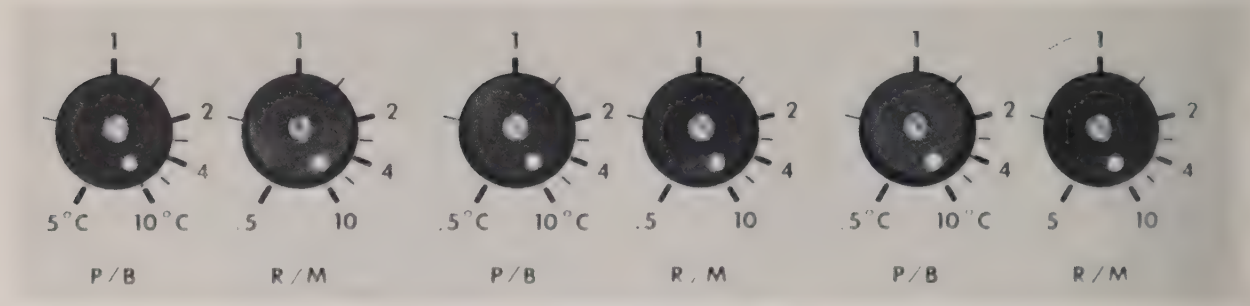


FIGURE 8 P/B and R/M Adjustment Panel

All Thermco's Ana-Lock Controllers feature two mode controls usually called Proportioning Plus Automatic Reset.

The first mode, proportioning, controls power to the SCR trigger circuits in direct proportion to thermocouple temperature deviation from set point dial indication. The proportional band is a selected range deviation of temperature required to control from 0% to 100% power output. The Proportional Band range is adjustable from 0.5°C to 10°C. Thermco Series 421 and 431 controllers' Proportional Band is adjustable between 5° and 100°C per channel (Zone Control).

A thermal difference between furnace and controller set point produces an offset voltage sensed in the operational amplifier as a percentage of Proportional Band range. Automatically the operational amplifier responds with a proportional change in output current of appropriate polarity.

The second mode of control, Automatic Reset, provides a complimentary shift of the Proportioning Band so that the Controller Set Point and the control temperature within the furnace tube coincide.

Reset action will continue and power output will increase (or decrease) with time until the offset voltage signal is eliminated.

As an example, assume that the initial power change was +10% and the reset rate is set at one repeat per minute. Power will increase proportionately with time at the rate of 10% per minute until either:

1. Thermal deviation is reduced, or
2. 100% power output is reached.

The term, "repeats per minute," is derived from the increase of corrective action with time and not from any cyclic action as is often assumed.

Employing too narrow a proportioning band or too fast a reset rate will likely produce temperature cycling. This is usually an undesired type of operation.

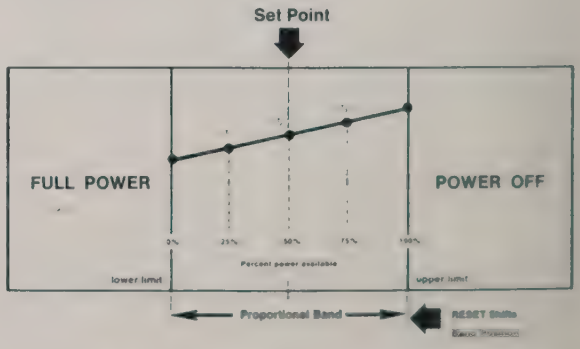


FIGURE 9 Power vs. Temperature in Proportional Band

CALIBRATION PROCEDURES

GENERAL

Calibration and Test Procedures are listed in the order of their inter-dependence. The controller should be turned on and allowed to stabilize for a minimum of 15 minutes prior to calibration. Reference to section containing schematics will show that each card has its own numbering system, R1, R2, etc., such that component numbers may be repeated from card to card. Total calibration of the instrument is necessary only when major rework has been done. All cards within this instrument are directly interchangeable with like cards received from the factory. All new cards from the factory are calibrated prior to shipment. Either an identical spare instrument back plate or a Thermco Test Set is necessary to set up calibration tests for the instrument.

CALIBRATION EQUIPMENT

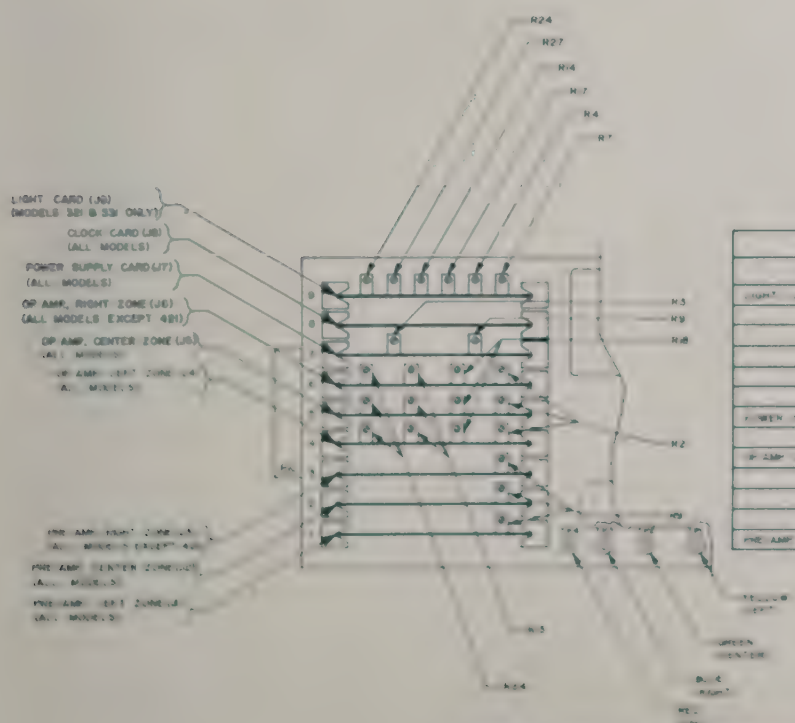
The following equipment is mentioned in this procedure and will be used during the course of Ana-Lock Controller instrument calibration:

A. Oscilloscope filter consisting of: 39K, ½ watt resistor and 25 mfd, 25 WVDC capacitor.
B. Millivolt Potentiometer: L & N or equivalent.
C. Zero to 20 Millivolt Source, 5 ohm max. output impedance: L & N or equivalent.
D. Output meter assembly (Models 321, 331). Three load resistors 1 K, ½ watt. Three 0 to 5 milliammeters.
E. Tektronix Oscilloscope or equivalent with min. sensitivity of 10 to 20 mv/cm.
F. Differential or Digital Voltmeter: Fluke #801B, Non-Linear Systems #X2, or equivalent.
G. Thermco Instrument "Back Panel" (same as instrument to be tested).

POWER SUPPLY (Refer to figure 10, Card Slot 7)

Two identical series-regulated power supplies of opposite polarities are used in the instrument. The rectifier diodes, regulator amplifiers, reference diodes and trimmer adjustments are mounted on the power supply card. The supply transformer, filter capacitors and output transistors are mounted on the main chassis (see figure 14).

Voltage measurements are made at the connector pins of the left end zone pre-amp card, slot one (see figure 36). A digital or differential voltmeter with floating input should be used.



CALIBRATION ADJUSTMENTS		
CARD	POT	FUNCTION
[illegible]	R7	[illegible]
	R4	[illegible]
	R1	[illegible]
	R14	[illegible]
	R27	[illegible]
	R24	[illegible]
[illegible]	R3	[illegible]
	R9	[illegible]
[illegible]	R2	[illegible]
	R8	[illegible]
	R5	[illegible]
	R14	[illegible]
[illegible]	R9	[illegible]

FIGURE 10 Ana-Lock Card Locator Drawing

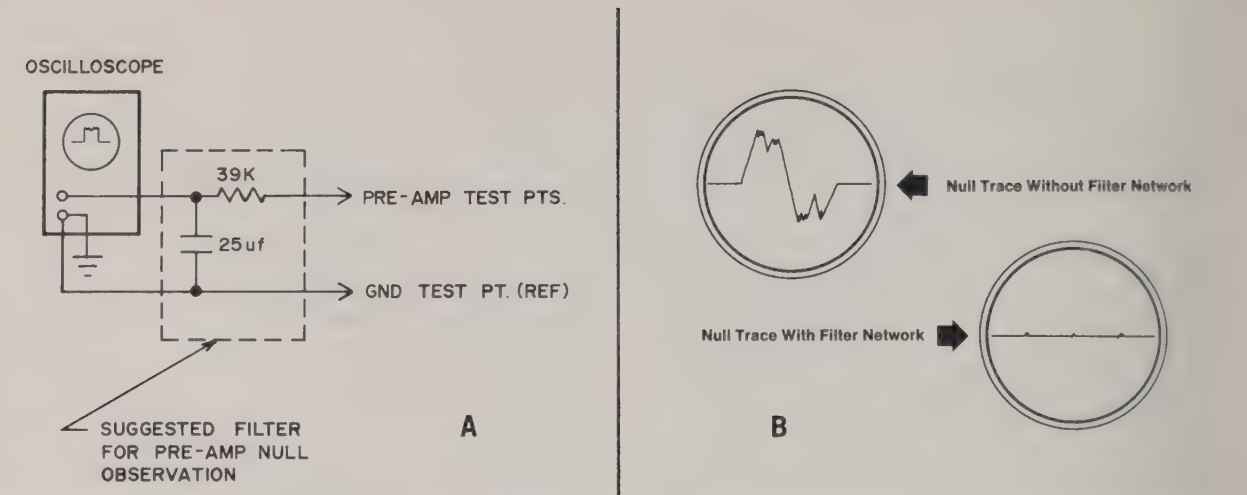


FIGURE 11 Oscilloscope Null Filter Drawing

PLUS 30 VOLTS: Connect negative lead of voltmeter to ground (red test point). Touch positive lead to pin 3 of the left zone pre-amp card. Adjust R9 for +30 volts ± 0.1 volt. (Turning screw slot clockwise increases voltage.)

MINUS 30 VOLTS: Connect lead of voltmeter to ground (red test point). Touch the negative lead to pin 13 of the left zone pre-amp card. Adjust R3 for —30 volts ± 0.1 volt. (Turning clockwise increases voltage.)

CLOCK CARD (Refer to figure 10, card slot 8)
The input Schmidtt trigger circuit is driven by a 60 Hz half-wave picked up from terminal 13 of the power supply card. This drives a flip-flop circuit producing a square wave of —20 volts peak (pin 9) and its 180° complementary phase (pin 10). These signals are used to drive the synchronous modulator and demodulator in each pre-amplifier card. No adjustment is required but these square waves may be checked at pins 1 and 2 of the left zone pre-amplifier, card slot one, figure 36.

PRE-AMPLIFIERS (Refer to figure 10, card slots 1, 2, 3)
All pre-amplifier cards contain a comparison circuit, modulator, A.C. amplifier, demodulator and reference circuit. Center zone and end zone pre-amplifiers differ only in the comparison and reference circuit resistor values.

Center Zone (Refer to figure 10, card slot 2)
Initial calibration voltages for the center zone (master) will be found in the range table and are set by trimmer resistor R9, see figure 13.

To calibrate this card, connect the digital or differential voltmeter (with floating input) with the positive lead to ground (red test point) and the negative lead to the clockwise end (terminal nearest to front panel) of the center zone set point potentiometer. Adjust R9 to the value in range table (CCW rotation increases voltage). Construct a scope input filter as shown in figure 11A.

NOTE: This filter is not supplied by Thermco. Connect the filter between the controller TEST POINTS and an oscilloscope (having a sensitivity of 10-20 mv/cm or better) to be used as a null detector.

Scope Settings: 0.1 v/cm vertical deflection D.C. mode, 5 milliseconds/cm horizontal sweep rate line sync.

L & N potentiometer or equivalent with MV run-up box should be used for precision calibration. See example following: For a functional test, a resistor of 2700 ohms connected across the CZ thermocouple input terminals will produce an offset equivalent of approximately 650°C. Scope should show a null when dial reads approximately 650°C, see figure 11B.

EXAMPLE: To calibrate at 1000°C, set L & N and MV run-up box to equivalent mv output voltage with proper cold junction compensation as indicated in the standard T/C voltage tables.

E output = (MV 1000°C) — (MV ambient °C)

Adjust set point dial to 1000°C. Null detector should indicate null condition. If not, readjust R9 (slot 2) for null. To verify correct operation of comparison circuit,

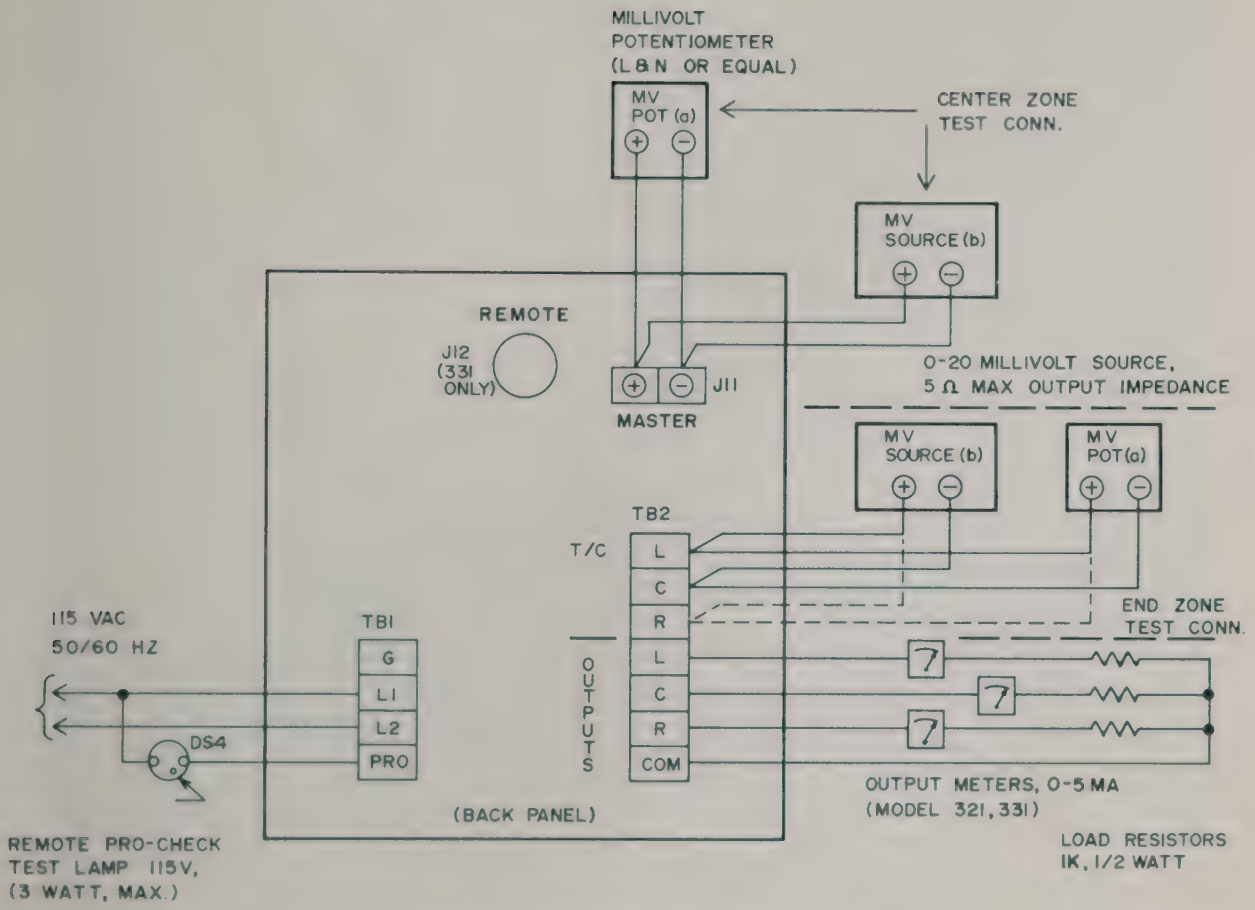


FIGURE 12 Calibration Using Back Panel Assembly

adjust set point dial to read 200 digits. (200°C above lower end of instrument range). Adjust MV source for null. Use L & N to measure millivoltage with cold junction compensation. When converted to °C, this value should agree with dial indication within a tolerance of +3°C to —3°C.

PRE-AMP END ZONE SERIES 201 and 321 (Refer to figure 10, card slots 1 and 3)

To calibrate end zones, T/C terminals may be shorted at back panel to provide equivalent offset of 0°C. Connect positive lead of VM to ground (red test point) and negative lead to clockwise end (terminal closest to front panel) of the right zone set point pot. Adjust right zone R9 for —0.200 volts. Move negative lead to left zone pot and repeat above for this zone. Observe null trace on scope. End zones should null at approximately 500 on the digital dial.

SERIES 331 WITH REMOTE SET POINT DIALS

Remote set point assembly must be connected to back plate remote socket. To calibrate right zone pre-amp card, unplug left zone pre-amp card. Connect VM as explained in Series 201, 321 end zone calibration procedure. Set R9 for —0.104 volts. Now unplug right zone pre-amp and move VM to terminal of left zone set point potentiometer. Plug in left zone pre-amp card and again adjust left zone R9 for —0.104 volts.

Plug in right zone card. VM should now read —0.200 volts, ± 0.001 volts.

CENTER ZONE SERIES 331

Calibration procedure is the same as Series 201 and 321 using center zone potentiometer terminal nearest remote plate.

SERIES 421 and 431

For two and three independent channels, calibrate all zones according to center zone procedure for Model 321. Refer to figure 13 for calibrating voltages.

GAIN TEST

Set controller dial and MV source for null at 1000°C Adjust dial 10° off null point. Output to oscilloscope should be 400 mv average with filter (see figure) or 800 mv p.p. square wave without filter. Acceptable limits are between 360 and 440 mv. Gain of Series 431 and 421 pre-amps should be 36 to 44 mv.

OPERATIONAL AMPLIFIER (Refer to figure 10, card slots 4, 5 and 6)

Two functions with separate inputs are included in this card module. The first of these is the Deviation Meter Amplifier, driven directly from the output of the pre-amp. This is a differential meter amplifier with balance (meter zero) controlled by R24 with corresponding pre-amp card at null point. Meter calibration is controlled by trimmer R18. This circuit is not used in Model 201, 421 and 431 controllers.

To calibrate the deviation meter, mechanical zero of meter should be properly set before starting. Adjust set point dial for null on oscilloscope and set trimmer R24 to obtain zero on deviation meter. Adjust set point dial for 800 mv deviation above null point, pointer should swing left. Adjust R18 for —20° indication on deviation meter.

The second function is the proportioning plus reset amplifier which is driven from the output of the P/B potentiometer connected as an attenuator in the pre-amp output. A reset lockout circuit is provided which discharges stored potential in reset capacitor when preset signal level is reached.

ADJUSTMENT PROCEDURE

Set P/B and R/M to maximum (full clockwise) and adjust controller for null on oscilloscope using RC filter. Turn R13 clockwise to end point to disable reset lockout temporarily. Turn R2 (balance adj.) clockwise until output drifts up to approximately 1 ma or CCW if output is above 1 ma. Adjust R2 until output remains constant without apparent drift (approximately 1/10 ma or less per minute).

Adjust set point dial 20°C above null position. Hold this setting for 2 to 3 minutes allowing reset capacitor to become fully charged. Adjust set point dial to approximately 2°C above null point (50 to 100 mv average pre-amp output). Output meter will now indicate approximately full output (5 ma).

Adjust R13 (Reset Lockout) CCW until output meter begins to drop below full output (5 ma). When output reaches approximately 4 ma, adjust R13 to hold 4 ma, approximately 80% of output.

Now set dial to 10° above null position. Output meter should go to maximum.

RESISTOR VALUES FOR T/C TYPE – RANGE

[Adjust **R9**]

T/C	RANGE	R-1	R-2	R-3	R-5	PART. NO.	⊛ CALIB. VOLT.
R	400°C – 1400°C	10M	187 Ω	15.6K	1.6K	06-262-08	-1.585
	200°C 1200°C	10M	116 Ω	13.2K	2.0K	06-262-24	-1.314
S	400°C – 1400°C	10M	208 Ω	14.2K	2.0K	06-262-23	-1.440
	200°C – 1200°C	10M	135 Ω	12.2K	2.2K	06-262-25	-1.200
K	200°C – 1200°C	3.3M	208 Ω	53.3K	JUMPER	06-262-22	-5.340
	0°C – 1000°C	3.3M	110 Ω	46.6K	JUMPER	06-262-26	-4.700

FIGURE 13 Center Zone Resistor Selector Chart

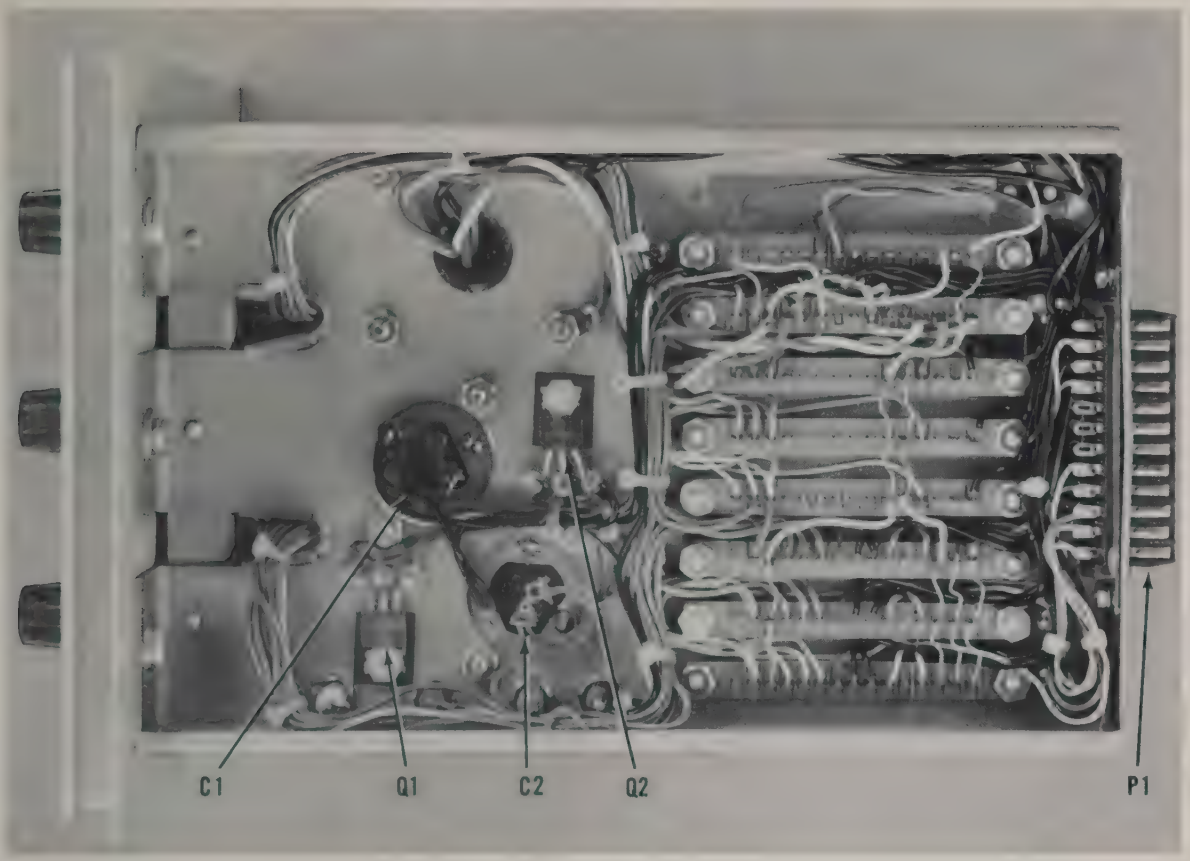


FIGURE 14 Bottom View Controller Main Chassis, Series 431

The calibration of all controllers not equipped with Pro-Check indicators is now complete.

PRO-CHECK LIGHT CARD (Refer to figure 10, card slot 9) The Pro-Check indicator system provides a warning lamp that illuminates whenever furnace temperature in any zone is above or below set point limits by more than preset values. These limits are factory set at ± 2°C. They can be field adjusted to other values between ± 1 and ± 10° deviation.

A relay (117 VAC) circuit is provided for a remote lamp which will illuminate whenever **any** zone exceeds a limit. Load on this circuit should not exceed 3 watts.

ADJUSTMENT

Left End Zone: Adjust input to zone until pre-amp output is at null. Left zone light should be out. If light remains on, alternately adjust R7 CCW and R4 CW until light is extinguished.

Increase set point dial setting by 2° or amount equal to desired low temperature limit. Slowly adjust R7 CCW if light is on and CW if light is off until light limit switching point is reached. Carefully swing adjustment slowly through this switching action several times reducing amount of rotation until point is definitely established where light just remains off.

Adjust zone set point dial to setting 2° below null point or an amount equal to the desired high limit. Slowly adjust R4 CW if light is on and CCW if light is off until switching point is reached. Refine adjustment, as necessary, in the same manner as with the low limit above. The left zone is now adjusted.

Center Zone: Repeat procedures as above using R17 for low limit and R14 for the high limit. **Right Zone:** Repeat above procedures using R27 for low limit and R24 for the high limit.

Adjustment of all controllers with Pro-Check light card is now complete.

SECTION VI

TROUBLESHOOTING

FAULT LOCATION CHART

When a malfunction has been isolated to the instrument or connecting system, the following symptoms and causes should be followed in locating the fault. All Operational Amplifier cards are interchangeable within the controller as are the end zone Pre-Amp cards and all Pre-Amp cards in the series 421 and 431. All cards shipped from the factory come precalibrated and ready to plug in.

SYMPTOM	INVOLVEMENT	POSSIBLE CAUSES
Full output	All zones	Shorted center zone T/C. Power supply (chassis card) Clock Card
Full output	One zone	Shorted T/C Pre-Amp card OP-Amp card SCR unit
No output	All zones	Open center zone T/C No control power —Power supply (chassis card) Clock card
No output	One zone	Open T/C Pre-Amp card OP-Amp card SCR unit
No output	Both end zones	Open center zone Ref. T/C Shortedcenter zone Ref. T/C
Partial to full output not responsive	Two zones	Clock card
Partial output Not responsive to Dial/Temp change	One zone	Pre-Amp card
Control functions OK, Pro-Check lights erratic or unresponsive	Any zone	Light Card

It is recommended that at least one full set of spare cards be available for maintenance. Card of same number (06-262-xx) may be interchanged within controller or exchanged with functioning controller to isolate faulty card.

Where deviation meter is included, localizing Pre-Amp vs. Op-Amp card problems is facilitated.

SCHEMATIC SERIES 201 CONTROLLER

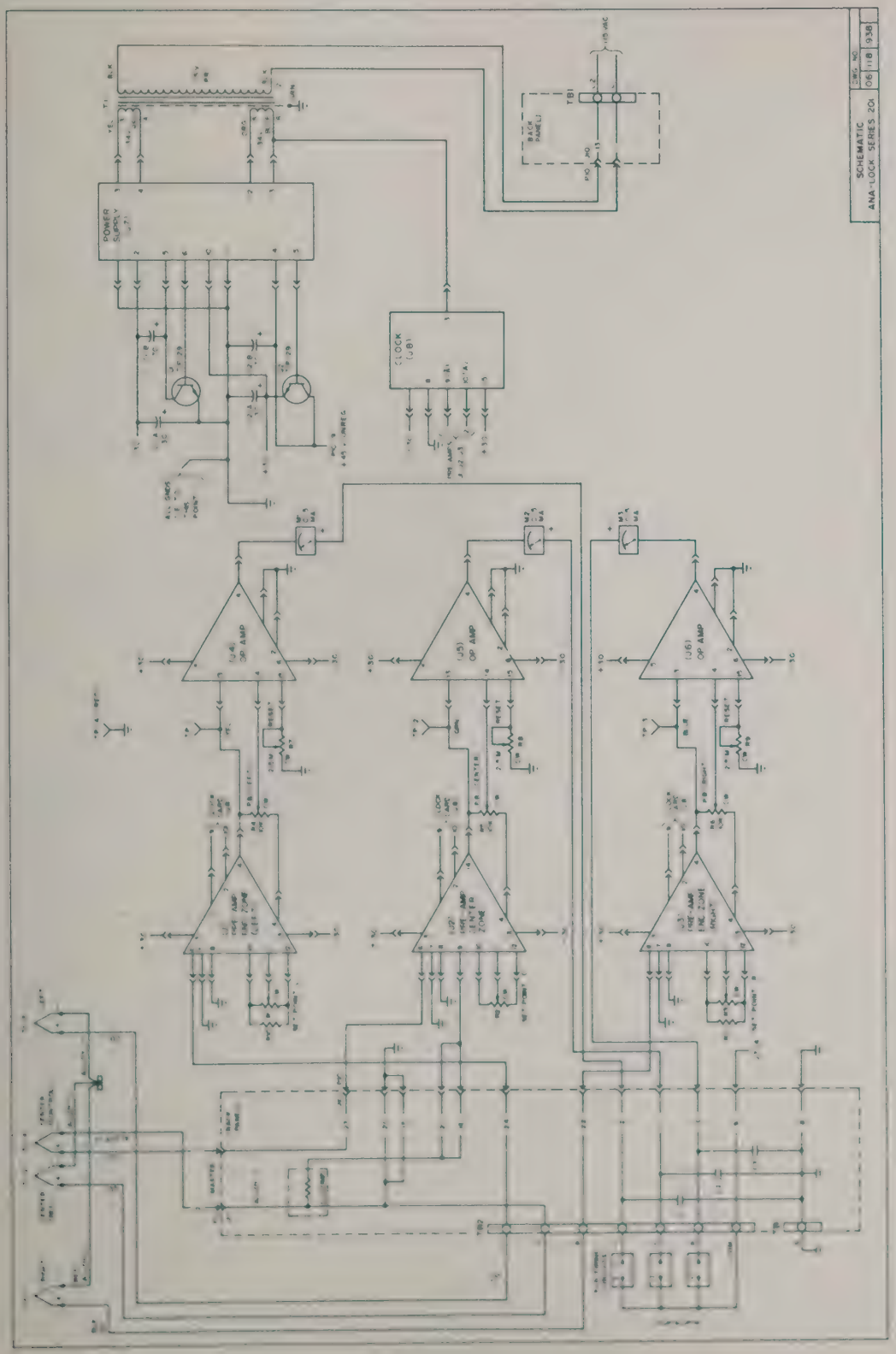
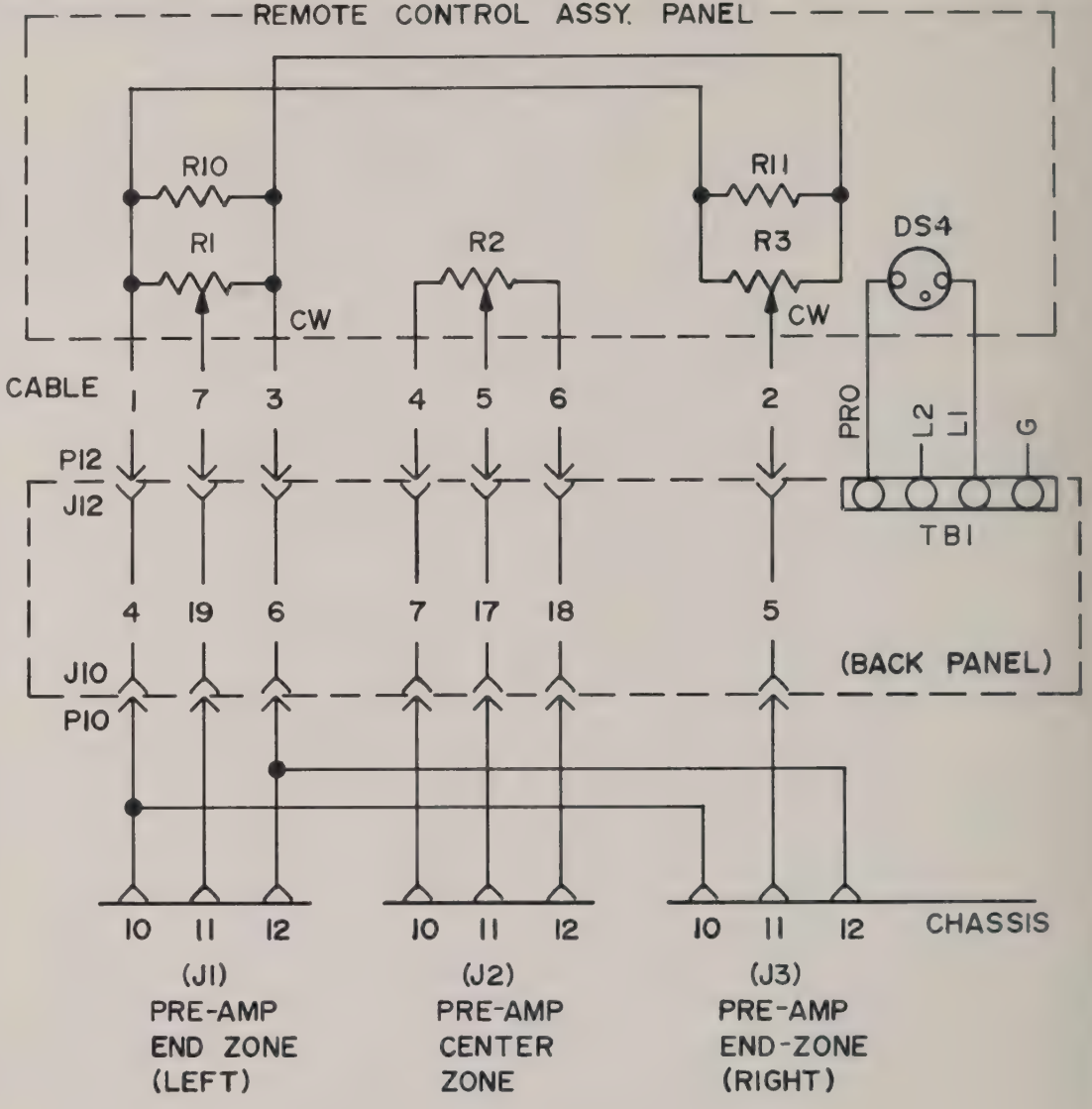


FIGURE 15 Model 201 Controller Schematic



NOTE:

1. CIRCUITRY FOR THE SERIES 331 IS IDENTICAL TO THE CIRCUITRY OF THE SERIES 321, EXCEPT FOR THE SET POINT POTENTIOMETER ON THE PRE-AMPS. THE DIFFERENCES ARE AS PER THIS DRAWING.

SCHEMATIC ANA-LOCK SERIES 331	DWG. NO. 06	418	214	

FIGURE 16 Remote Control, 331 Schematic

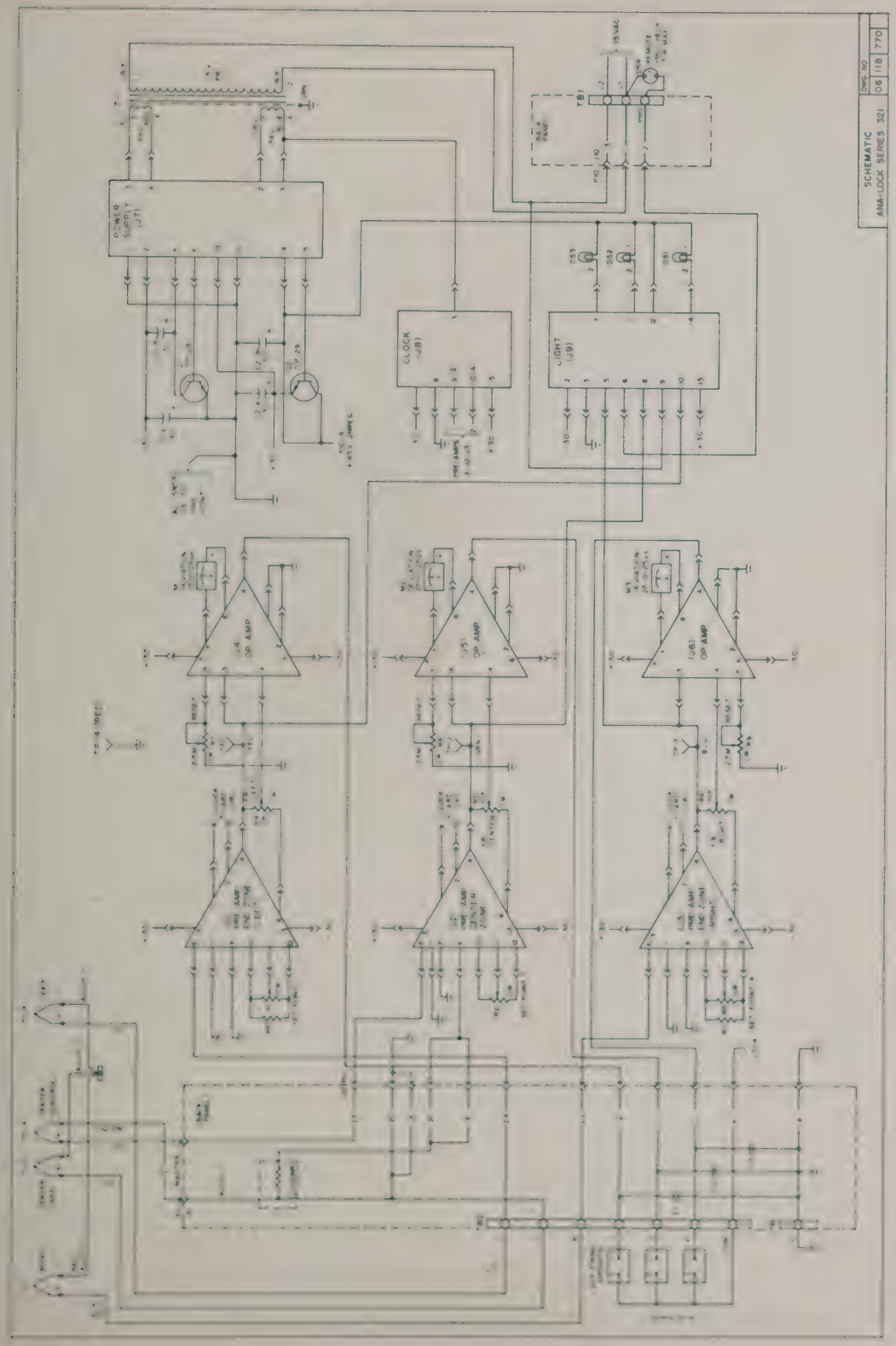


FIGURE 17 Model 321 Controller Schematic

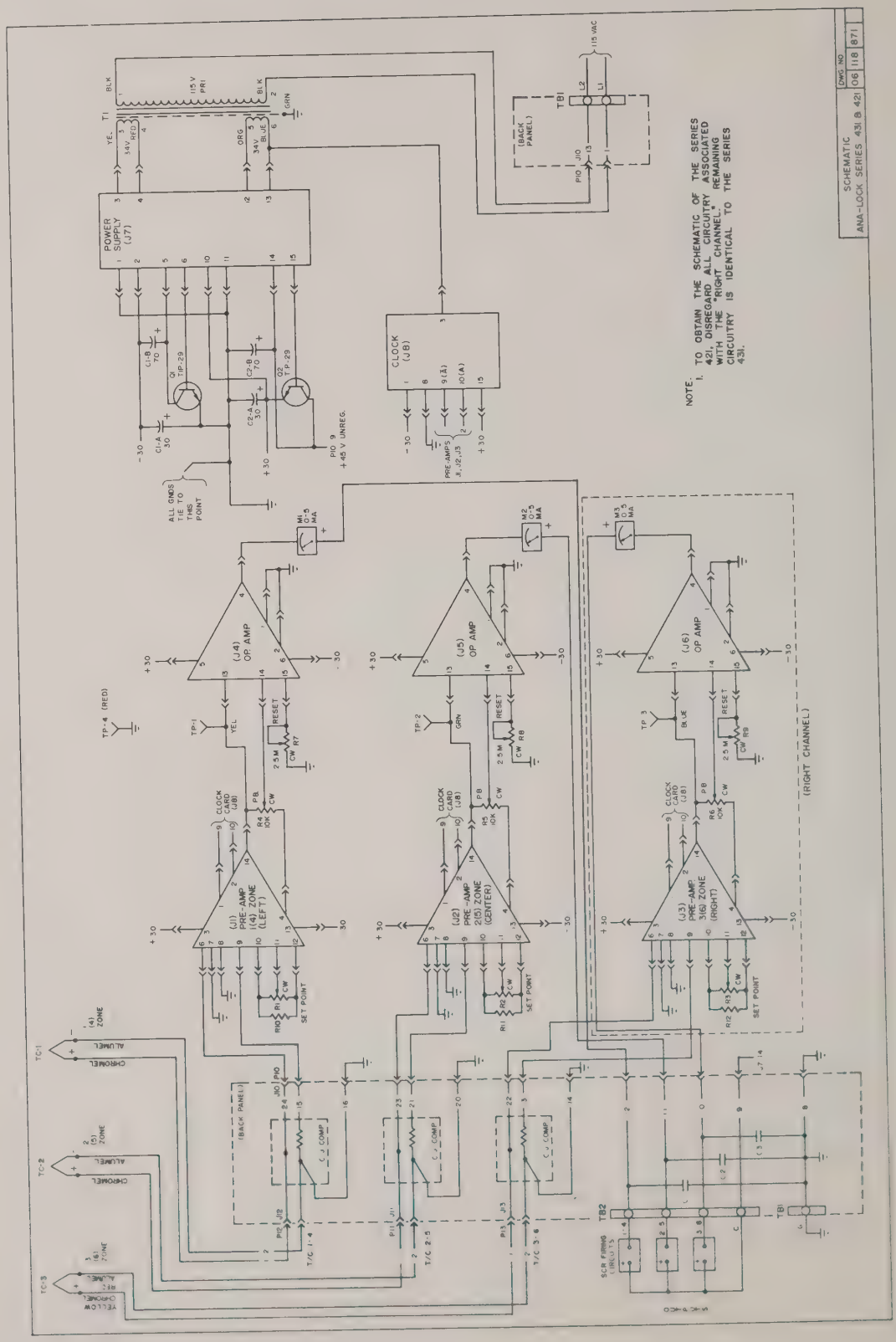


FIGURE 18 Model 421, 431 Controller Schematic

MAIN CHASSIS PARTS LIST

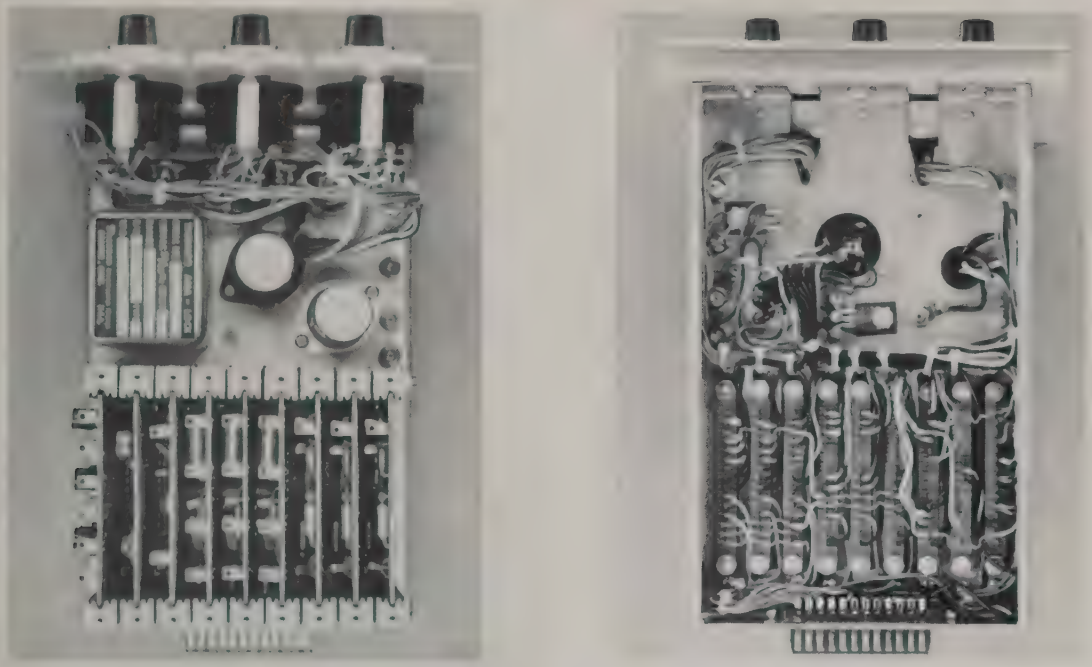
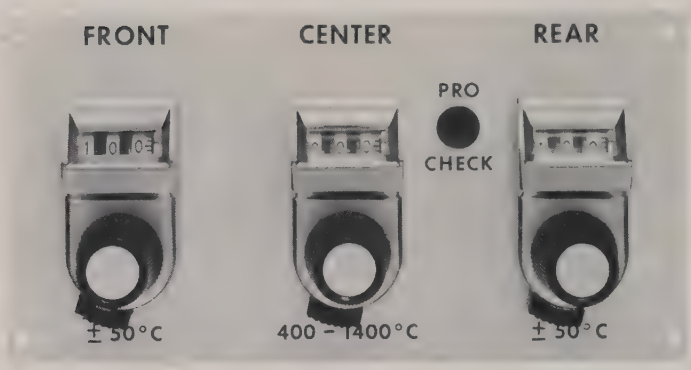


FIGURE 19 Top and Bottom Views Main Controller Chassis, Series 321

CHASSIS ASSEMBLY
All Series

COMPONENT	DESCRIPTION	NUMBER	201	321	331	421	431
Q1, Q2	TRANSISTOR	TIP-29	2	2	2	2	2
R10, R11	RESISTOR 53.6Ω 1%	CCA-TO (RN60D)	2	2	—	—	—
	RESISTOR 649Ω 1%	Type 135	—	—	—	2	3
R7, R8, R9	POTENTIOMETER 2.5 MEG	CTS 6314	3	3	3	2	3
R4, R5, R6	POTENTIOMETER 10 K	CTS 6741	3	3	3	2	3
R2	POTENTIOMETER CHARACTERIZED 490Ω	MOD 3230-1625	1	1	—	—	—
R1, R3	POTENTIOMETER LINEAR 500Ω	3253	2	2	—	—	—
R1, R2, R3	POTENTIOMETER LINEAR 2 K	3253	—	—	—	2	3
	COVER, PLATE	06-480-19	1	1	1	—	—
	COVER, PLATE	06-480-23	—	—	—	1	—
	COVER, PLATE	06-480-21	—	—	—	—	1
	KNOB, INDICATOR	06-458-1	6	6	6	4	6
	DATA NAMEPLATE, THERMCO ANA-LOCK	06-422-32	1	1	1	1	1
T1	POWER TRANSFORMER	06-345-2	1	1	1	1	1
C1-2	CAPACITOR 70/30 MF 150V	TVL 2439	2	2	2	2	2
TP-1	JACK YELLOW	105-607	1	1	1	1	1
TP-2	JACK GREEN	105-604	1	1	1	1	1
TP-3	JACK BLUE	105-610	1	1	1	1	1
TP-4	JACK RED	105-602	1	1	1	—	1
	TRANSISTOR INSULATOR (Q1, Q2)	43-77-2	2	2	2	2	2
J1-J9	CONNECTOR, P.C. BOARD	SAC 15 S/1-2	8	9	9	6	8
P10	CONNECTOR, PLUG	26-4100-24P	1	1	1	1	1
	GROMMET, NYLON STRIP	GSN3	2	2	2	2	2
Q1, Q2	WASHER, FIBER	2153	2	2	2	2	2
M1, M2, M3	METER, DEVIATION 25-0-25μa	AA-114700-65	—	3	3	—	—
M1, M2, M3	METER, OUTPUT 0-5 MA	20118010-147	3	—	—	2	3
DS1, DS2, DS3	RED LIGHT ASSEMBLIES 28V, .04a	G5-2311T	—	3	3	—	—
	DIAL COUNTER	DFD-1N	3	3	—	2	3
	STAND OFF TERMINAL	93-1503	6	6	6	6	6
	POLARIZING KEY	007900	8	9	9	6	8

PARTS LIST AND PHOTO, SERIES 331 REMOTE PANEL



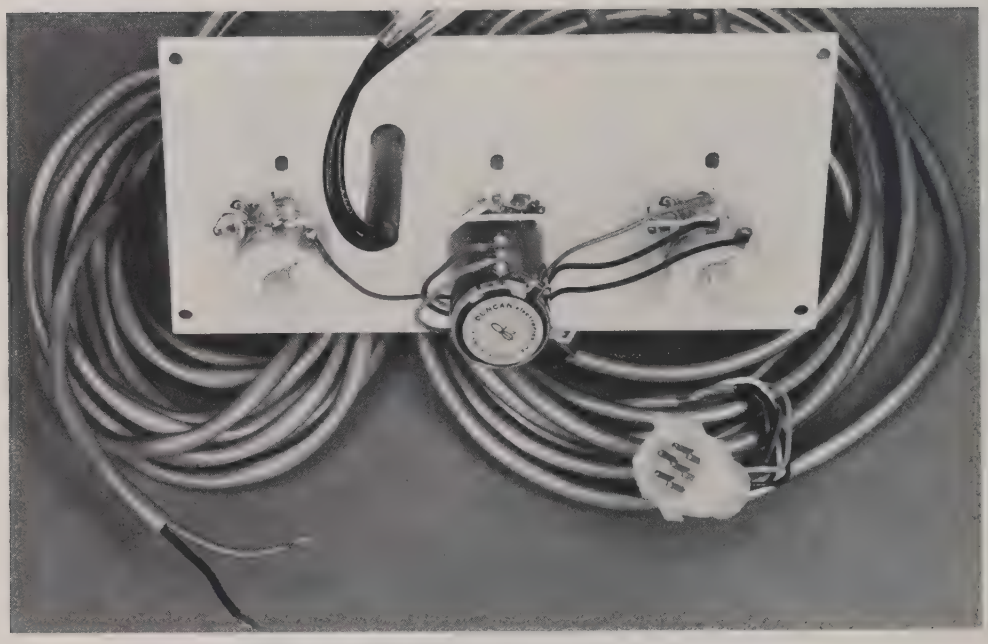


FIGURE 20 Front and Rear View 331 Remote Control Panel

REMOTE CONTROL ASSEMBLY
Ana-Lock Series 331

COMPONENT	DESCRIPTION	PART NUMBER
R10, R11	RESISTOR 53.6Ω, 1%	CCA-TO(RN60D)
R1, R3	POTENTIOMETER 500Ω	3253
R2	CHARACTERIZED POT. 490Ω	3230-1625
P12	PLUG	1 – 480-420-0
P12-x	MALE PIN (X amount)	61061-1
DS4	INDICATOR LAMP	36N2311
	WIRE, TWISTED PAIR 2 COND. #22GA	1631
	CABLE 7 COND, #22GA	1177
	DIAL, COUNTER	DFD1N

BACK PANEL PARTS LIST AND PHOTOS

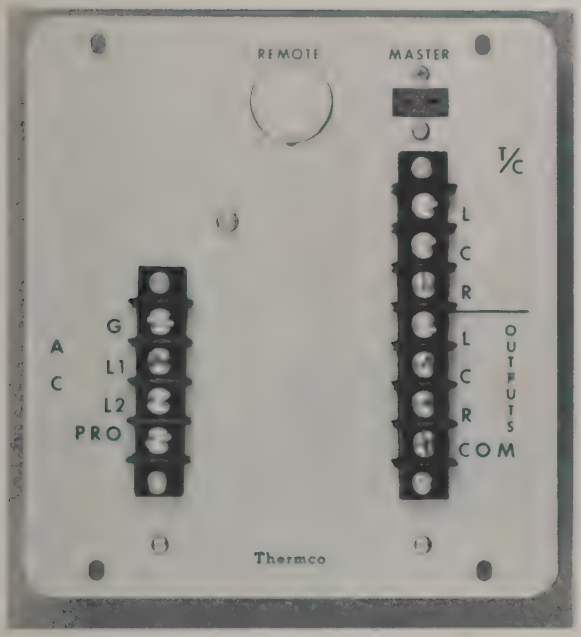


FIGURE 21 Model 321 Back Panel Connector Side

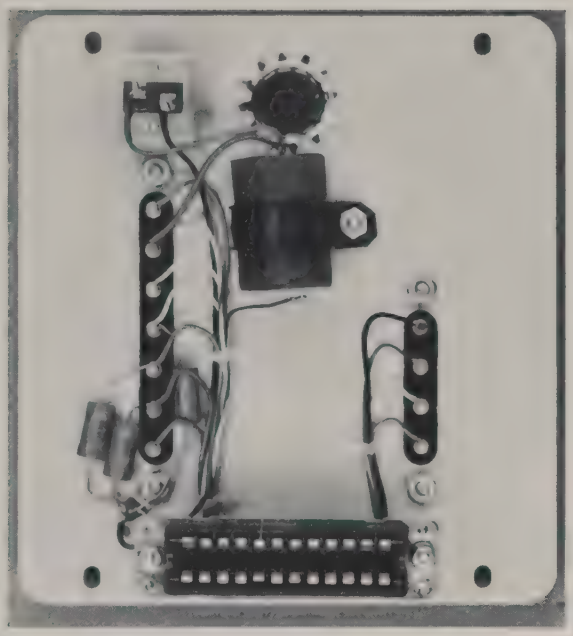


FIGURE 22 Model 321 Back Panel Component Side

BACK PANEL ASSEMBLIES

All Series

DESCRIPTION	NUMBER	201	321	331	421	431
CAPACITOR, .1MF, 200V	192P-10492	3	3	3	2	3
COLD JUNCTION COMPENSATOR	06-401-19	1	1	1	—	—
COLD JUNCTION COMPENSATOR	06-401-20	—	—	—	2	3
TERMINAL BLOCK	GFT-3	—	—	—	2	1
TERMINAL BLOCK	GFT-4	1	1	1	—	1
TERMINAL BLOCK	GFT-7	1	1	1	—	—
CONNECTOR	26-4200-24S	1	1	1	1	1
T/C RECEPTACLE	23517-MSJ-SX	1	1	1	—	—
T/C RECEPTACLE	23517-MSJ-KX	—	—	—	2	3
RETAINER, RECEPTACLE (T/C)	01-432-171	1	1	1	2	3
SOCKET, COMP. W (7) FEM. PINS #61063-1	1-480-421-0	—	—	1	—	—
SPACER ⅞"	8724	2	2	2	2	2
BUTTON HOLE PLUG ¾"		1	1	—	—	—
PLASTIC 'C' CLAMP		1	1	1	2	3
TERMINAL LUG	1416-6	1	1	1	1	1
BACK PANEL	01-380-05	1	1	1	—	—
BACK PANEL	06-380-44	—	—	—	1	—
BACK PANEL	06-380-38	—	—	—	—	1

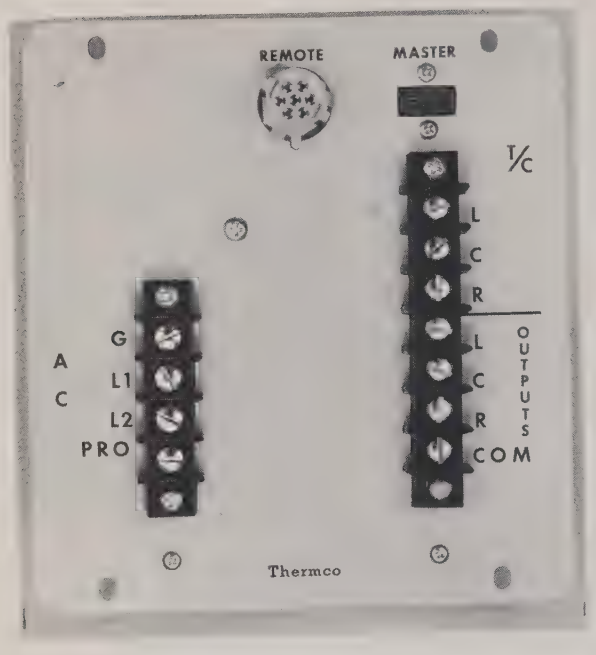


FIGURE 23 Model 331 Back Panel Connector Side

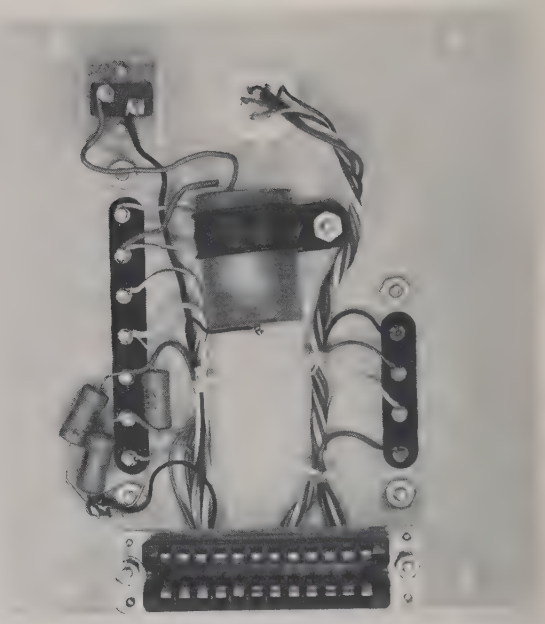


FIGURE 24 Model 331 Back Panel Component Side

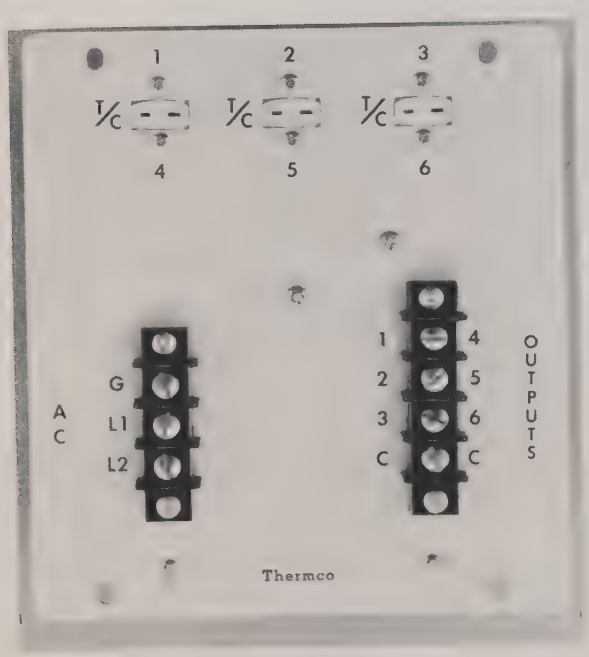


FIGURE 25 Model 431 Back Panel Connector Side

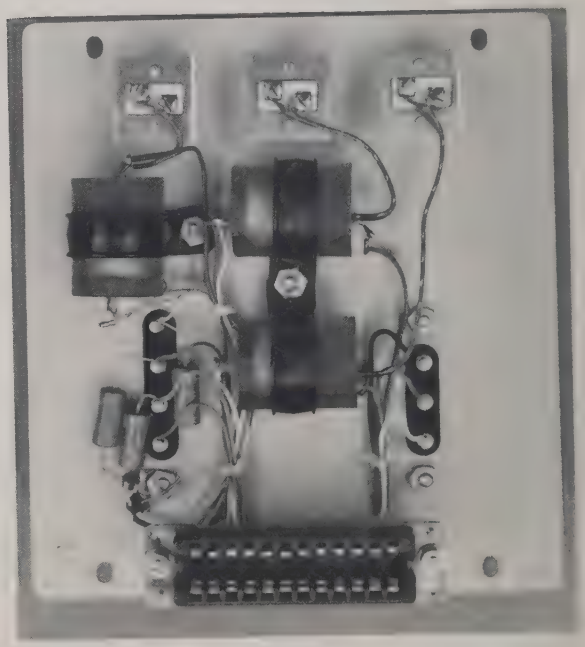


FIGURE 26 Model 431 Back Panel Component Side

CONTROLLER CARD REQUIREMENTS

There follows, on the next 12 pages, complete data to facilitate calibration and troubleshooting of all Thermco's Ana-Lock Controller circuit cards.

On facing pages are Call Out Photos, Parts Lists and a complete Schematic for each of the six card types used in Thermco Controllers. In addition, where applicable, related exterior circuitry is included to illustrate that particular circuit card's interface with the rest of the controller's circuits. Further interconnections between card and Controller can be found on schematic pages:

19 Series **201** Controller,
20 Series **331** Remote Controller,
21 Series **321** Controller,
22 Series **421, 431** Controllers.

All active components are called out on actual photos to simplify component location. It should be noted that circuit symbols Q1, Q2, etc. repeat themselves from card-to-card. Card component numbers apply to that circuit card only.

STANDARD CARD and FUNCTION	Ana-Lock Card Requirements — Quantity Per Controller				
	201	321	331	421	431
POWER SUPPLY 06-262-05	1	1	1	1	1
CLOCK 06-262-12	1	1	1	1	1
OPERATIONAL AMPLIFIER 06-262-06	3	3	3	2	3
PRO-CHECK LIGHT 06-262-10		1	1		
PRE AMP END ZONES, Type R/S 06-262-09	2	2	2		
PRE AMP CENTER ZONE, Type R, 400-1400°C 06-262-08	1	1	1		
PRE AMP INDEPENDENT ZONE, Type K, 200°C/1200°C 06-262-22				2	3

CENTER ZONE — Optional Calibrations		
CARD NO.	T/C	RANGE
06-262-23	S	400-1400°C
06-262-24	R	200-1200°C
06-262-25	S	200-1200°C
	INDEPENDENT ZONE	
06-262-26	K	0-1000°C

FIGURE 27 Ana-Lock Controller Card Requirements

POWER SUPPLY CARD PARTS LIST AND PHOTO

POWER SUPPLY CARD
No. 06-262-05
Ana-Lock Series 201, 321, 331, 421, 431

COMPONENT	DESCRIPTION	PART NUMBER
TRANSISTORS		
Q5, Q6, Q2, Q4		2N4062
Q1, Q3		2N3711
DIODES		
CR2, CR3, CR9, CR10		1N914
CR4, CR5, CR6, CR7, CR11, CR12, CR13, CR14		1N4003
CR1, CR8	6.2V ZENER	1N753A
RESISTORS		
R5, R11	220Ω, ¼W, 5%	RC07GF
R13, R14	3.3K, ¼W, 5%	RC07GF
R6, R12	47K, ¼W, 5%	RC07GF
R1, R7, R2, R8	2.7K, ¼W, 5%	RC07GF
R4, R10	1K, ¼W, 5%	RC07GF
POTENTIOMETERS		
R3, R9	2K	900-20-202
CAPACITORS		
C1, C2	.01MF, 100V	TA110

FIGURE 28 Power Supply Card Call Out Photo

POWER SUPPLY CARD SCHEMATIC

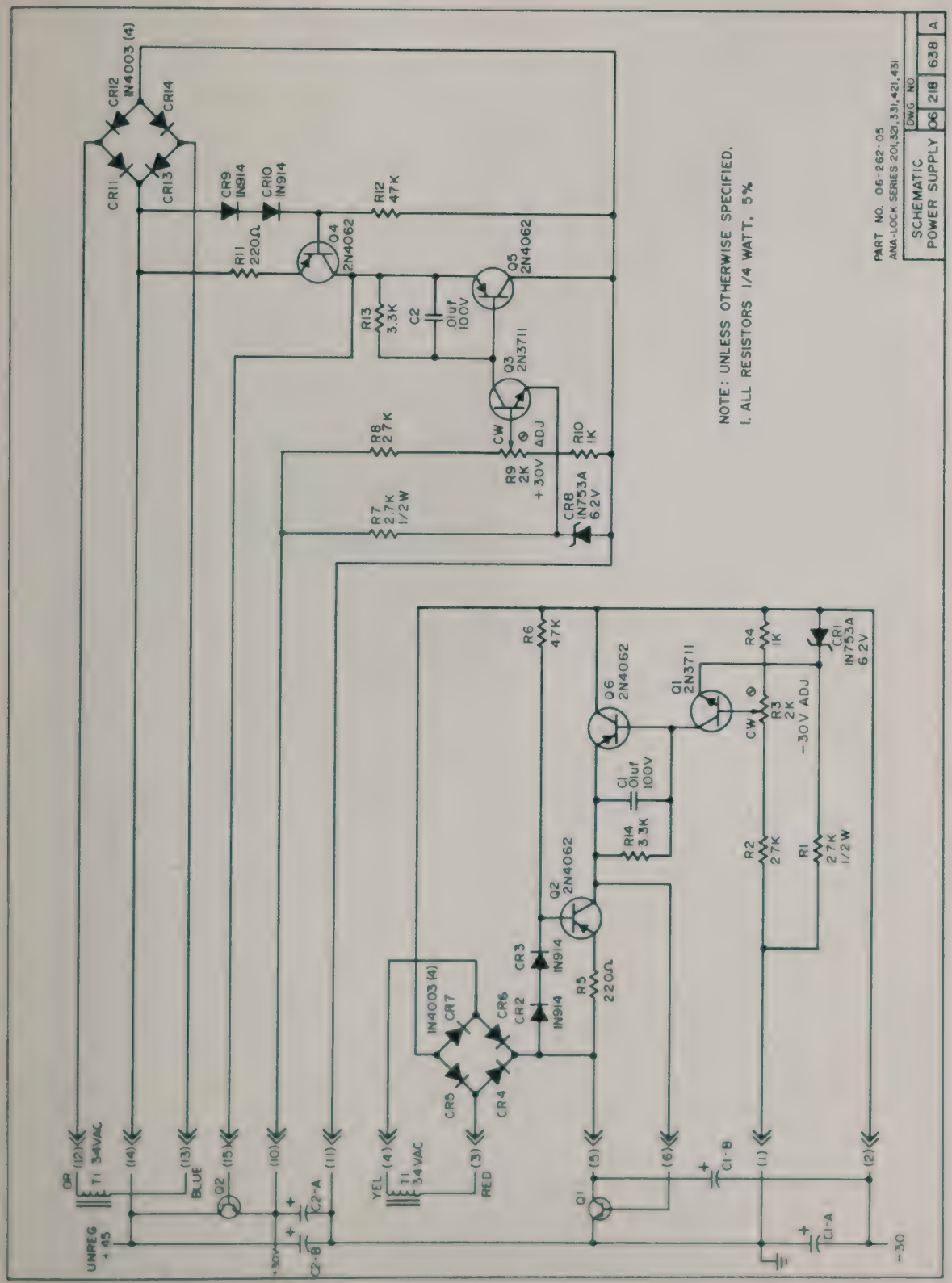


FIGURE 29 Power Supply Card Schematic

CLOCK CARD PARTS LIST AND PHOTO

CLOCK CARD
No. 06-262-12
Ana-Lock Series 201, 321, 331, 421, 431

COMPONENT	DESCRIPTION	PART NUMBER
TRANSISTORS		
Q1, Q2, Q3, Q4		2N4062
DIODES		
CR1, CR2		1N914
RESISTORS		
R4	4.7K, ¼W, 5%	RC07GF
R5, R6, R11, R12	10K, ¼W, 5%	RC07GF
R3, R7	22K, ¼W, 5%	RC07GF
R2	33K, ¼W, 5%	RC07GF
R8, R9, R13, R15	100K, ¼W, 5%	RC07GF
R10, R14	1M, ¼W, 5%	RC07GF
R1	56K, ¼W, 5%	RC07GF
CAPACITORS		
C2, C3, C4, C5	MICA 100pf	DM1501J
	MYLAR 0.1MF, 200V, 10%	192P-10492
C6		
C1	MYLAR .01MFD, 200V	192P-10392

FIGURE 30 Clock Card Call Out Photo

CLOCK CARD SCHEMATIC

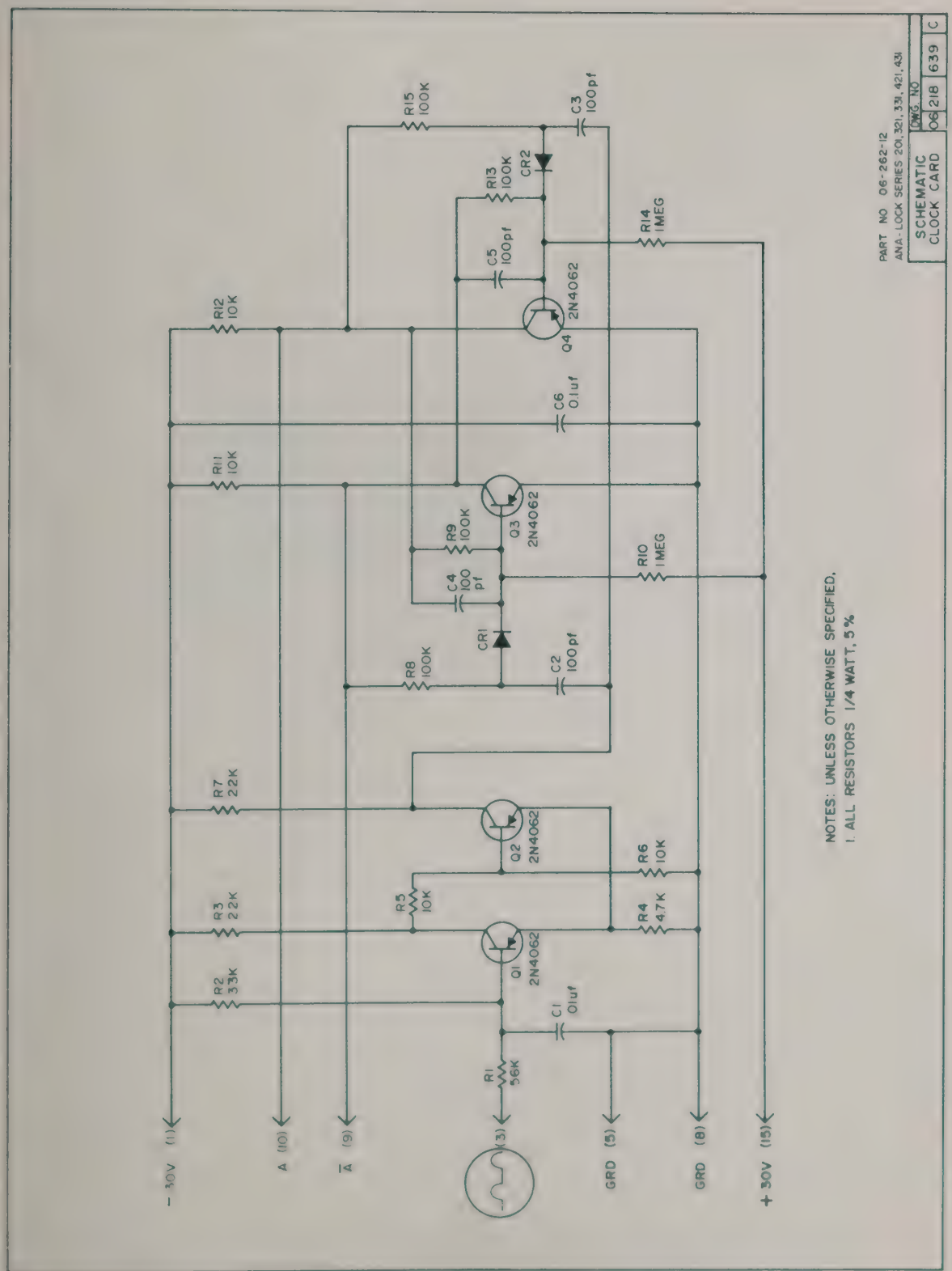


FIGURE 31 Clock Card Schematic

OPERATIONAL AMPLIFIER CARD PARTS LIST AND PHOTO

OPERATIONAL AMPLIFIER CARD
No. 06-262-06
Ana-Lock Series 201, 321, 331, 421, 431

COMPONENT	DESCRIPTION	PART NUMBER
TRANSISTORS		
Q1, Q7	DUAL	TD101
Q2, Q3, Q6		2N4062
Q4		2N3711
Q5		2N1613
DIODES		
CR1, CR2, CR3, CR4		1N914
RESISTORS		
R1, R3	39K, ¼W, 5%	RC07GF
R19	36K, ¼W, 5%	RC07GF
R4, R16, R22	1M, ¼W, 5%	RC07GF
R5	220K, ¼W, 5%	RC07GF
R6, R8, R28	56K, ¼W, 5%	RC07GF
R7	13M, ¼W, 5%	RC07GF
R9, R14	18K, ¼W, 5%	RC07GF
R10	5.1K, ¼W, 5%	RC07GF
R11	5.6K, ¼W, 5%	RC07GF
R12	100K, ¼W, 5%	RC07GF
R15	1.3K, ¼W, 5%	RC07GF
R26, R27	1K, ¼W, 5%	RC07GF
R23, R25	47K, ¼W, 5%	RC07GF
R17, R21	100K, ⅛W, 1%	RN55D
R20	2.7K, ¼W, 5%	RC07GF
POTENTIOMETERS		
R13, R18	20K	900-20-203
R2, R24	10K	900-20-103
CAPACITORS		
C1	2.7MF, 50V	CS13BG275K
C2	.0015MF, 100V	225P-15291
C3	.1MF, 200V	192P-10492
C4	150MF, 15V	CS13BD157K

FIGURE 32 Operational Amplifier Card Call Out Photo

OPERATIONAL AMPLIFIER SCHEMATIC

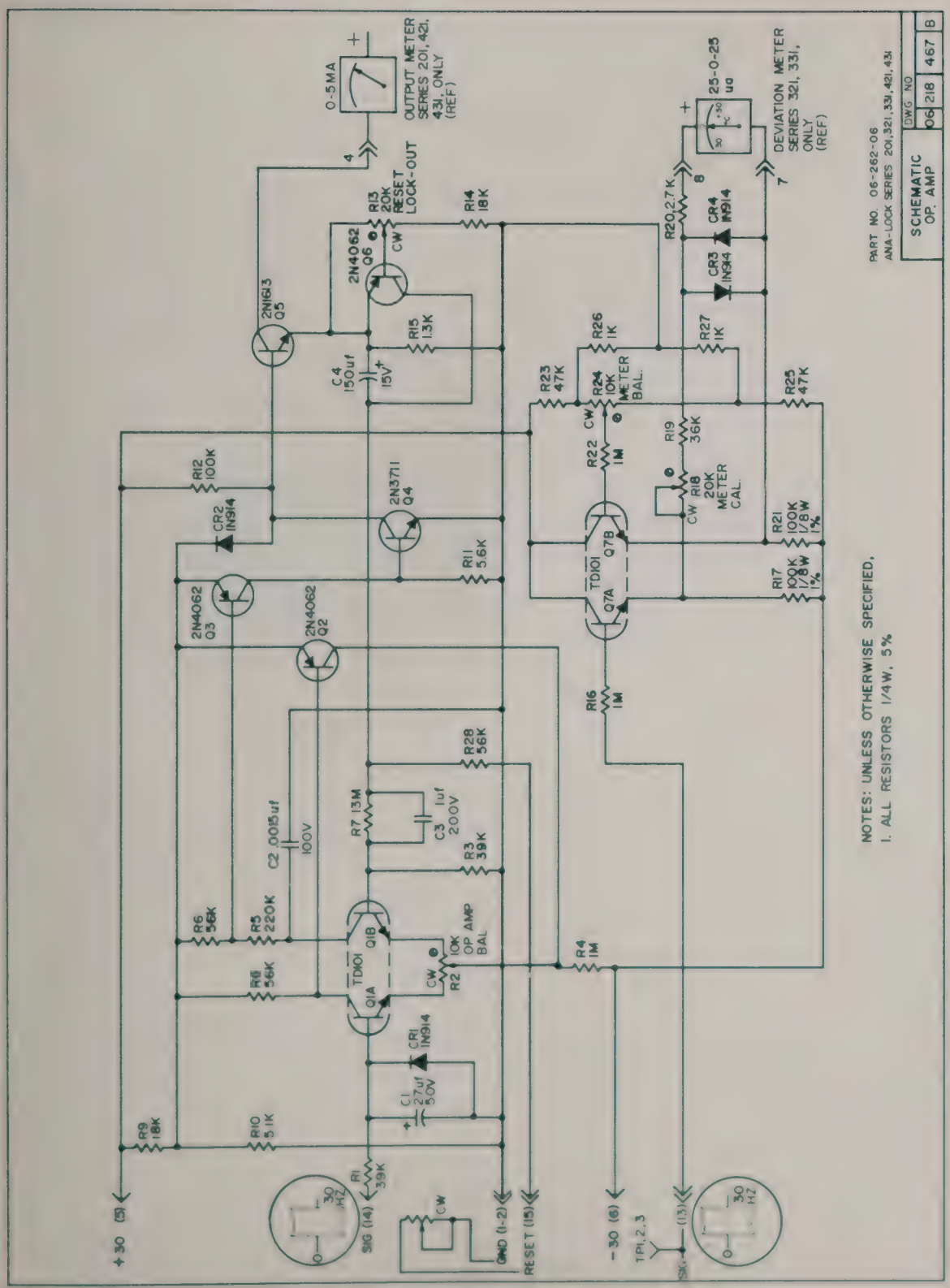


FIGURE 33 Operational Amplifier Card Schematic

PRE-AMP CARD — CENTER ZONE
No. 06-262-08
Ana-Lock Series 201, 321, 331, 421, 431

COMPONENT	DESCRIPTION	PART NUMBER
TRANSISTORS		
Q1, Q2, Q5, Q6		2N3824
Q3, Q4, Q7, Q8, Q9		2N3711
DIODES		
CR3	6.2V, T.C.	1N825
CR1, CR2, CR4, CR5		1N914
RESISTORS		
R4	1K, .1%	TYPE 243
R6, R7	10K, .1%	TYPE 243
R8	1M, .1%	TYPE 243
R5	1.6K, 1%	TYPE 243
R3	15.6K, 1%	TYPE 243
R2	187Ω, .1%	TYPE 243
R1	10M, ¼W, 5%	RC07GF
R10, R13	470K, ¼W, 5%	RC07GF
R11, R14	330K, ¼W, 5%	RC07GF
R12, R15	22K, ¼W, 5%	RC07GF
R16	33K, ¼W, 5%	RC07GF
R18, R26, R27, R21*	22M, ¼W, 5%	RC07GF
R20, R22	2.2M, ¼W, 5%	RC07GF
R23	27Ω, ¼W, 5%	RC07GF
R29, R25	1M, ¼W, 5%	RC07GF
R30	2.2K, ¼W, 5%	RC07GF
R31, R33	10K, ¼W, 5%	RC07GF
R32	510Ω, ¼W, 5%	RC07GF
R17*	1K to 10K, ¼W, 5%	Selected in Test RC07GF
R19	2K, ½W, 5%, ww	RG 20
POTENTIOMETER		
R9	500Ω	900-20-501
CAPACITORS		
C1, C2, C3, C4, C5, C7	47MF, 6V	CS13BB476K
C6, C11	1MF, 35V	CS13BF105K
C10	100PF	5GA-T10
C12	47MF, 35V	CS13BF476K
C8	4.7MF, 10V	CS13BC475K

* For type "K" Thermocouple, **–22** and **–26** Circuit Cards **R21** changed to **15 Meg** and **R17** changes **2.2K** (fixed)

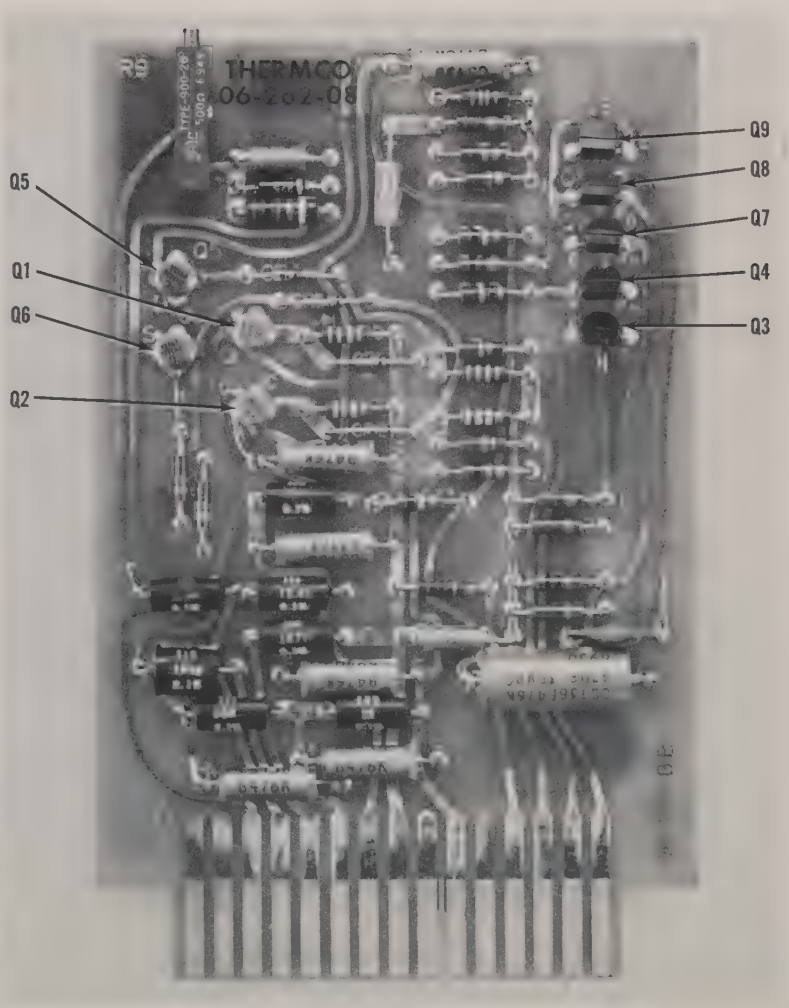


FIGURE 34 Center Zone Pre-Amplifier Card Call Out Photo

CENTER ZONE PRE-AMPLIFIER SCHEMATIC

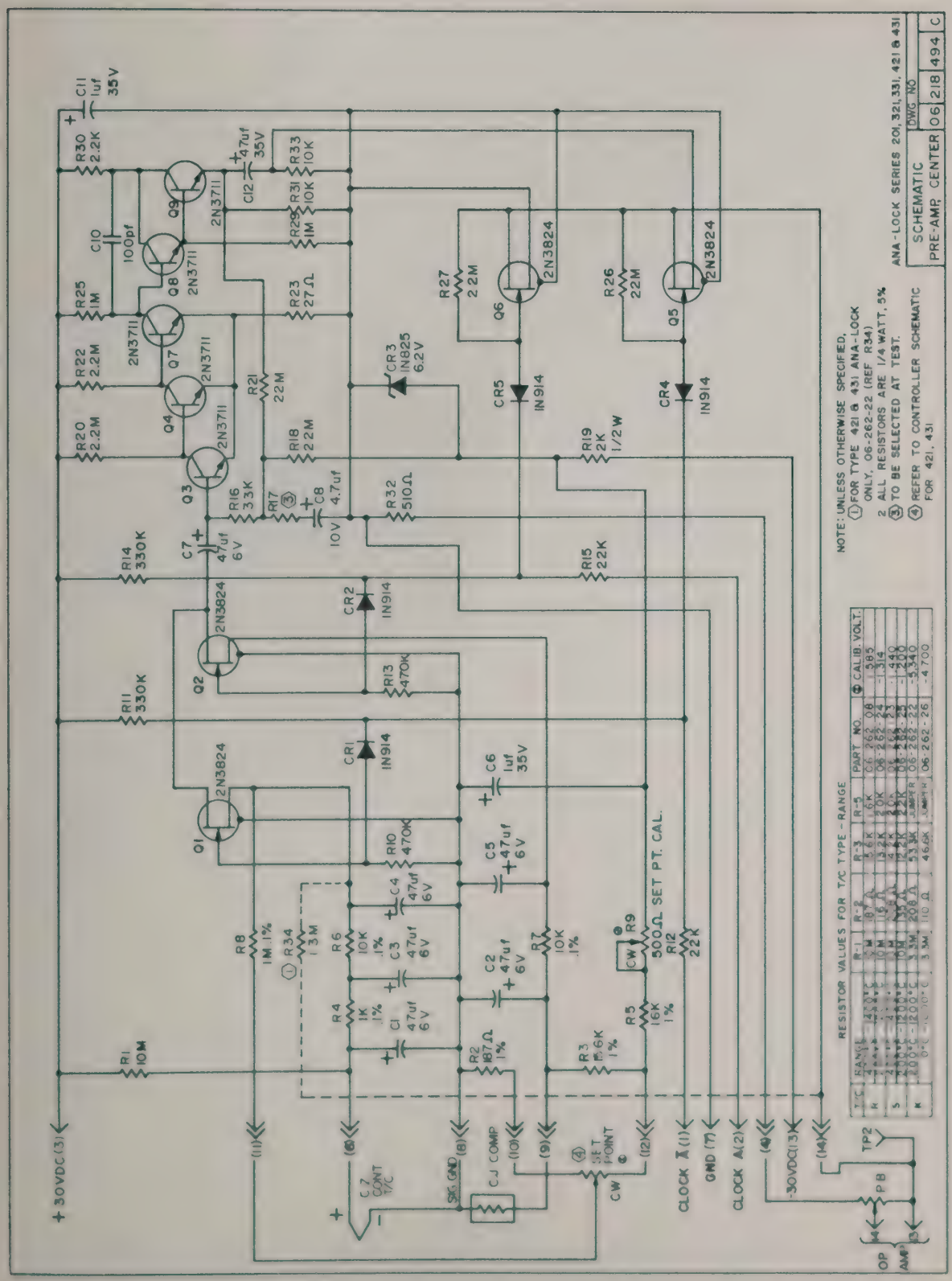

+30VDC(13)
-30VDC(13)
CLOCK A(2)
CLOCK Ā(1)
GND (7)
CJ COMP
SET POINT
500Ω SET PT. CAL.
TP2
OP AMP
NOTE: UNLESS OTHERWISE SPECIFIED.
① FOR TYPE 421 & 431 ANA-LOCK ONLY, 06-262-22 (REF R34)
② ALL RESISTORS ARE 1/4 WATT, 5%
③ TO BE SELECTED AT TEST.
④ REFER TO CONTROLLER SCHEMATIC FOR 421, 431
ANA-LOCK SERIES 201, 321, 331, 421 & 431
SCHEMATIC
PRE-AMP, CENTER
DWG NO 06 218 494 C
RESISTOR VALUES FOR T/C TYPE - RANGE

FIGURE 35 Center Zone Pre-Amplifier Card Schematic

PRE-AMP CARD — END ZONE
No. 06-262-09
Ana-Lock Series 201, 321 331

COMPONENT	DESCRIPTION	PART NUMBER
TRANSISTORS		
Q1, Q2, Q5, Q6		2N3824
Q3, Q4, Q7, Q8, Q9		2N3711
DIODES		
CR3 (Zener)	6.2V, 5%	1N753A
CR1, CR2, CR4, CR5		1N914
RESISTORS		
R4	1K, .1%	TYPE 243
R6, R7	10K, .1%	TYPE 243
R8	1M, .1%	TYPE 243
R3, R5	1.18K, .1%	TYPE 243
R2	6.5Ω, .1%	TYPE 243
R1	10M, ¼W, 5%	RC07GF
R10, R13	470K, ¼W, 5%	RC07GF
R11, R14	330K, ¼W, 5%	RC07GF
R12, R15	22K, ¼W, 5%	RC07GF
R16	33K, ¼W, 5%	RC07GF
R18, R26, R27, R21	22M, ¼W, 5%	RC07GF
R20, R22	2.2M, ¼W, 5%	RC07GF
R23	27Ω, ¼W, 5%	RC07GF
R29, R25	1M, ¼W, 5%	RC07GF
R30	2.2K, ¼W, 5%	RC07GF
R31, R33	10K, ¼W, 5%	RC07GF
R32	510Ω, ¼W, 5%	RC07GF
R17	1K to 10K	Selected in Test
R19	2K, ½W, 5%, ww	RG20
POTENTIOMETER		
R9	500Ω	900-20-501
CAPACITORS		
C1, C2, C3, C4, C5, C7	47MF, 6V	CS13BB476K
C6, C11	1MF, 35V	CS13BF105K
C10	100PF	5GA-T10
C12	47MF, 35V	CS13BF476K
C8	4.7MF, 10V	CS13BC475K

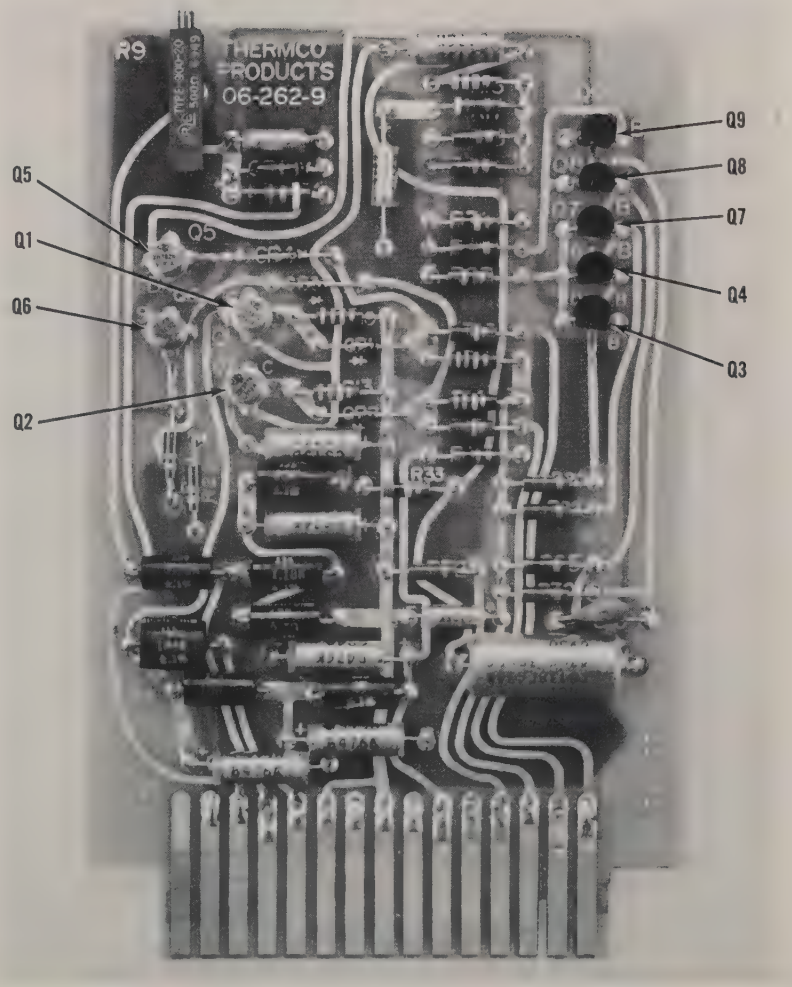


FIGURE 36 End Zone Pre-Amplifier Card Call Out Photo

END ZONE PRE-AMPLIFIER SCHEMATIC

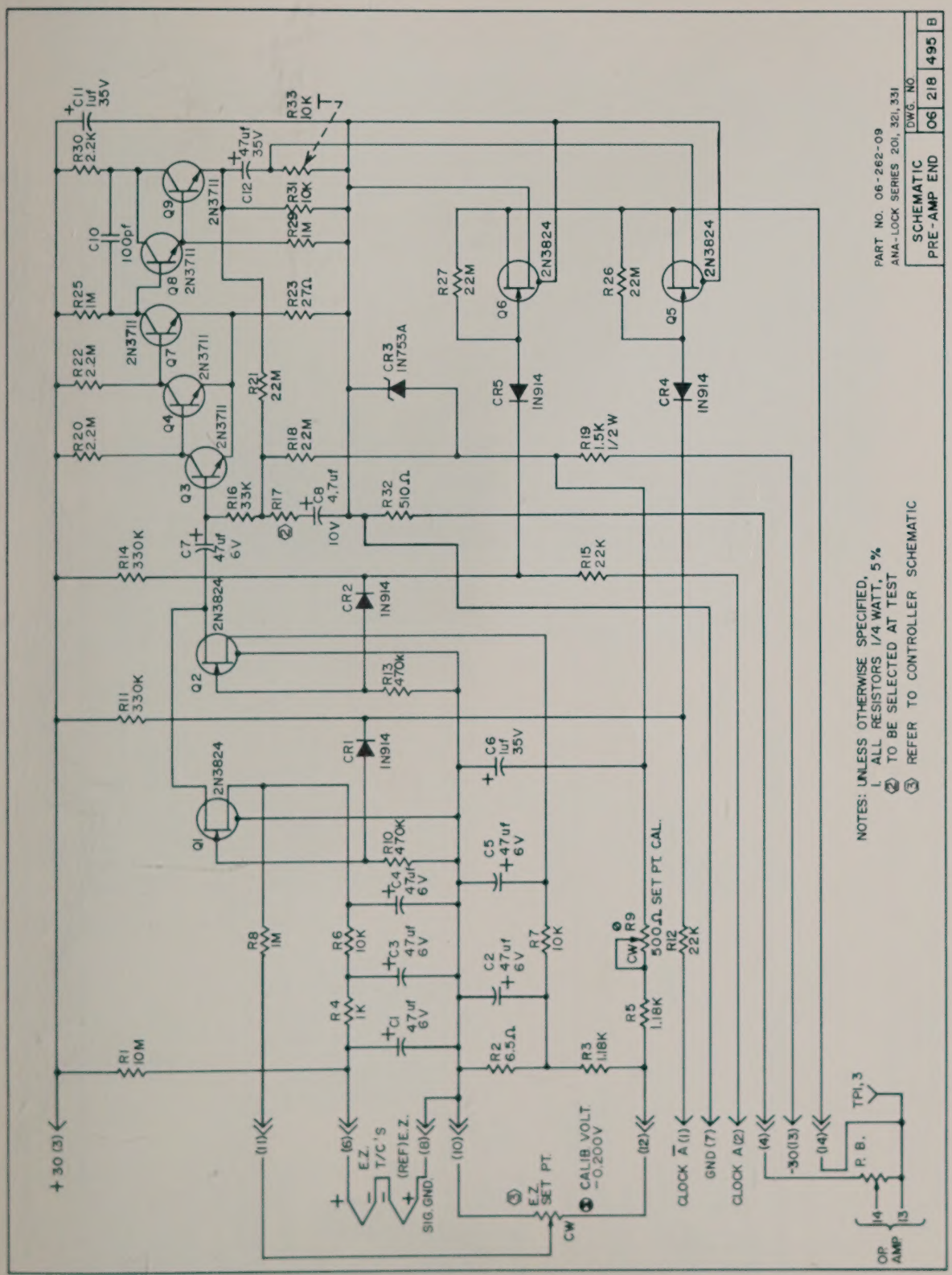


FIGURE 37 End Zone Pre-Amplifier Card Schematic

PRO-CHECK LIGHT CARD
No. 06-262-10
Ana-Lock Series 321, 331

COMPONENT	DESCRIPTION	PART NUMBER
TRANSISTORS		
Q1, Q2, Q6, Q7, Q11, Q12	DUAL	TD101
Q3, Q8, Q13, Q16		2N4062
Q4, Q9, Q14		2N5308
Q5, Q10, Q15, Q17		2N1613
DIODES		
CR1, CR2, CR3, CR4, CR5, CR6, CR7, CR8, CR9		1N914
CR10		1N4003
RESISTORS		
R1, R9, R11, R19, R21, R29, R31, R32	22K, ¼W, 5%	RC07GF
R3, R6, R13, R16, R23, R26	1 M, ¼W, 5%	RC07GF
R5, R15, R25	10K, ¼W, 5%	RC07GF
R8, R18, R28	47K, ¼W, 5%	RC07GF
R10, R20, R30	390Ω, 1W, 10%	RC32GF
R33, R38	27K, ¼W, 5%	RC07GF
R34, R37	470Ω, ¼W, 5%	RC07GF
R35, R36	100Ω, ¼W, 5%	RC07GF
R39	1.5K, ½W, 10%	RC20GF
R2, R12, R22	150K, ¼W, 5%	RC07GF
POTENTIOMETERS		
R4, R7, R14, R17, R24, R27	10K	900-20-103
CAPACITORS		
C1, C3, C5	47MF, 6V	CS13BB476K
C2, C4, C6	4.7MF, 10V	CS13BC475K
RELAY		
K1		JRM 1012

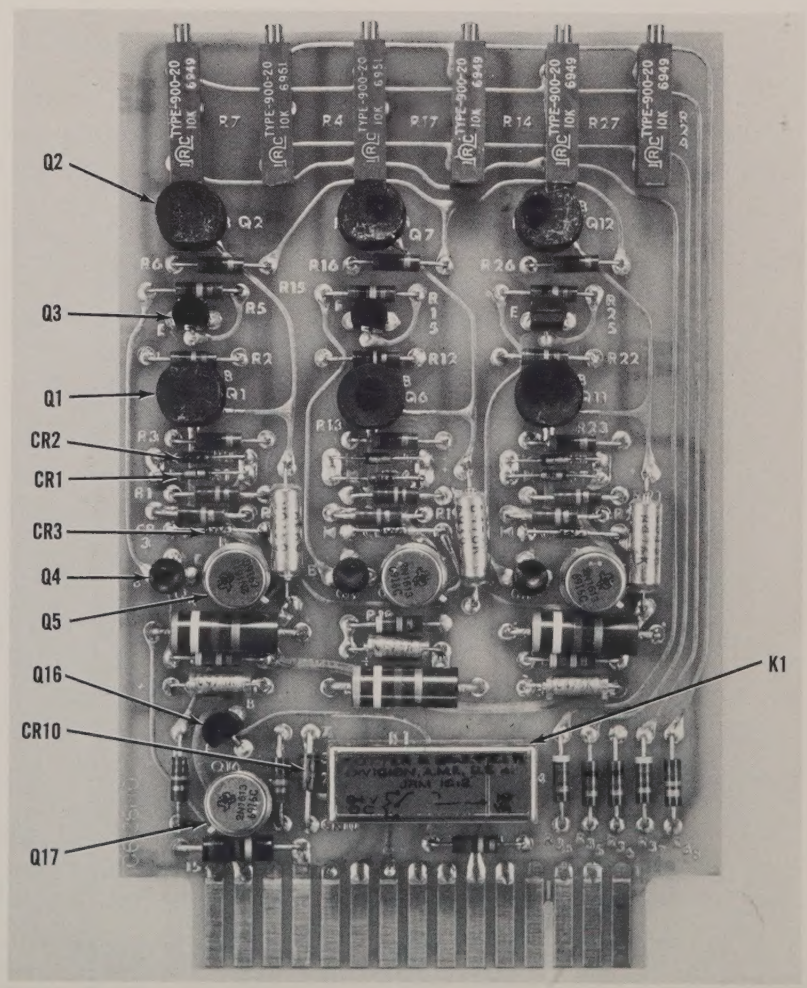


FIGURE 38 Pro-Check Light Card Call Out Photo

PRO-CHECK LIGHT CARD SCHEMATIC

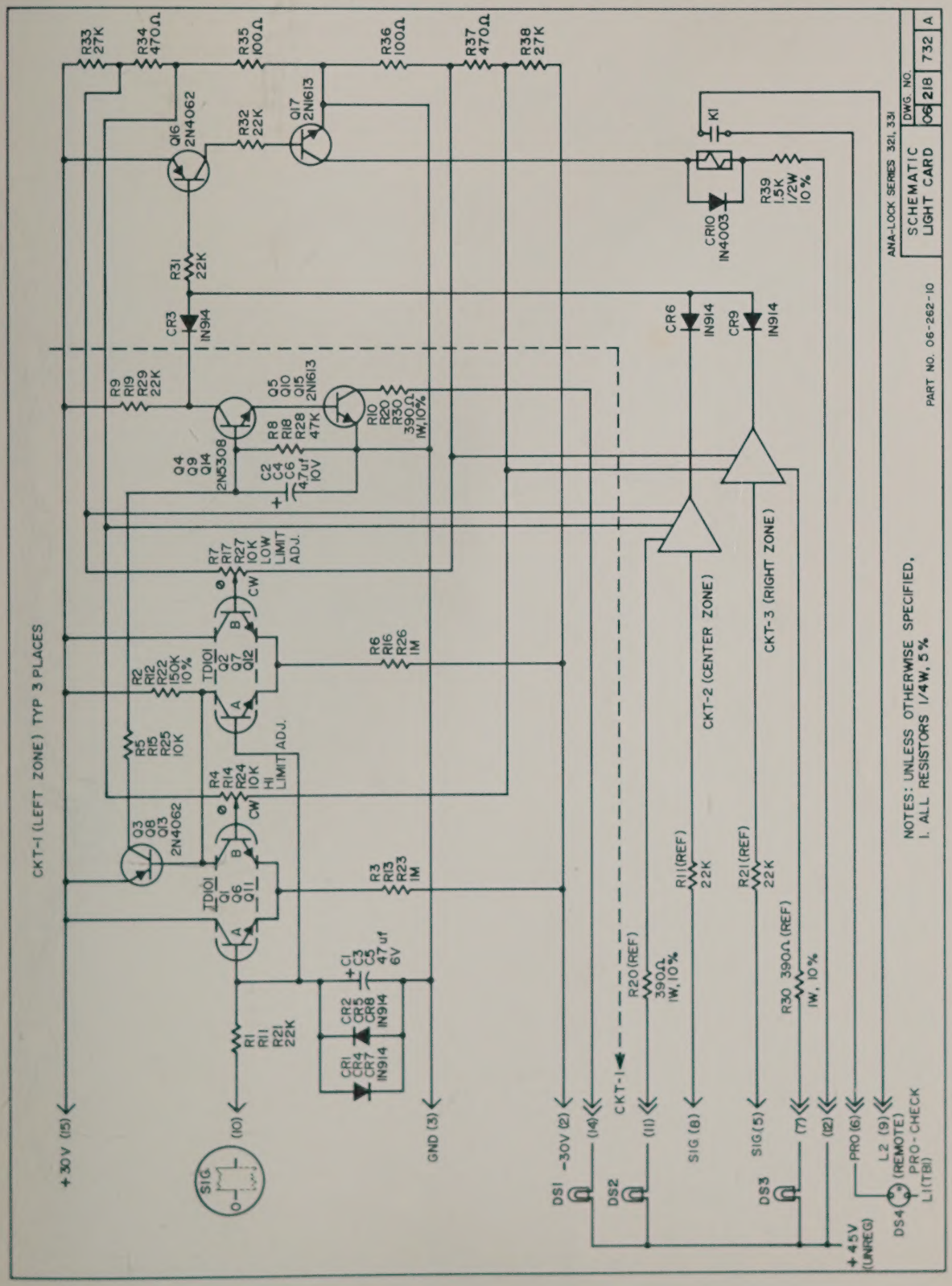


FIGURE 39 Pro-Check Light Card Schematic

SECTION IX

LIST OF ILLUSTRATIONS

FIGURE	DESCRIPTION	PAGE
1	Model 321 Ana-Lock Controller	3
2	Model 431 Ana-Lock Controller	3
3	Ana-Lock Controller Features	4
4	Diffusion Furnace Controller Installation	7
5	Diffusion Furnace	9
6	Conveyor Furnace	9
7	Block Diagram Model 201 Controller	10
8	P/B and R/M Adjustment Panel	12
9	Power vs. Temperature in Proportional Band	12
10	Ana-Lock Card Locator Drawing	13
11	Oscilloscope Null Filter Drawing	14
12	Calibration Using Back Panel Assembly	15
13	Center Zone Resistor Selector Chart	16
14	Bottom View of Controller Main Chassis	17
15	Model 201 Controller Schematic	19
16	Remote Control, 331 Schematic	20
17	Model 321 Controller Schematic	21
18	Model 421, 431 Controller Schematic	22
19	Top and Bottom Views Main Controller Chassis	23
20	Front and Rear View 331 Remote Control Panel	24
21	Model 321 Back Panel Connector Side	25
22	Model 321 Back Panel Component Side	25
23	Model 331 Back Panel Connector Side	26
24	Model 331 Back Panel Component Side	26
25	Model 431 Back Panel Connector Side	26
26	Model 431 Back Panel Component Side	26
27	Ana-Lock Controller Card Requirements	27
28	Power Supply Card Call Out Photo	28
29	Power Supply Card Schematic	29
30	Clock Card Call Out Photo	30
31	Clock Card Schematic	31
32	Operational Amplifier Card Call Out Photo	32
33	Operational Amplifier Card Schematic	33
34	Center Zone Pre-Amplifier Card Call Out Photo	34
35	Center Zone Pre-Amplifier Card Schematic	35
36	End Zone Pre-Amplifier Card Call Out Photo	36
37	End Zone Pre-Amplifier Card Schematic	37
38	Pro-Check Light Card Call Out Photo	38
39	Pro-Check Card Schematic	39

SECTION X

PACKING AND SHIPPING INFORMATION

A. If deemed necessary to return the controller to Thermco, careful packing can prevent damage in transit. Be certain that all cards are plugged firmly in place. Tape a rectangle of corrugated cardboard across face of meters for additional protection.

B. Provide a minimum of 2 inches of packing material on all sides of instrument. Clearly identify with appropriate labels identifying a delicate instrument. Carton strength should be a minimum of 150 pound test.

C. Include a copy inside the carton describing the reasons for returning the instrument and any steps taken to correct the controller fault. This will facilitate its repair at the factory.

D. Ship prepaid to:

THERMCO PRODUCTS CORPORATION
1465 North Batavia Street
Orange, California 92667
(714) 639-2340

VIKING LABORATORIES INC.

PRINTED IN U.S.A. 2M-5/70